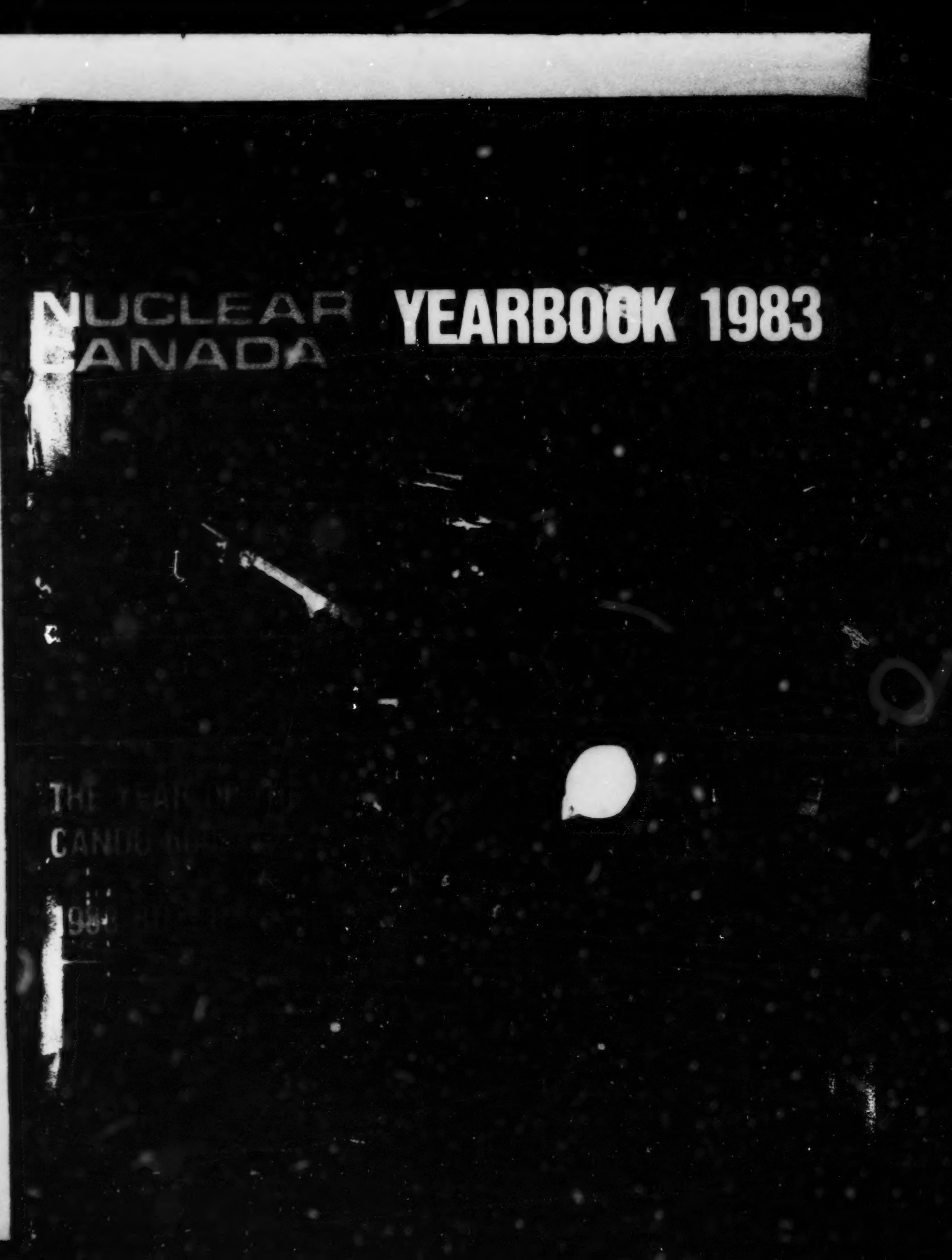
NUCLEAR CANADA YEARBOOK 1983



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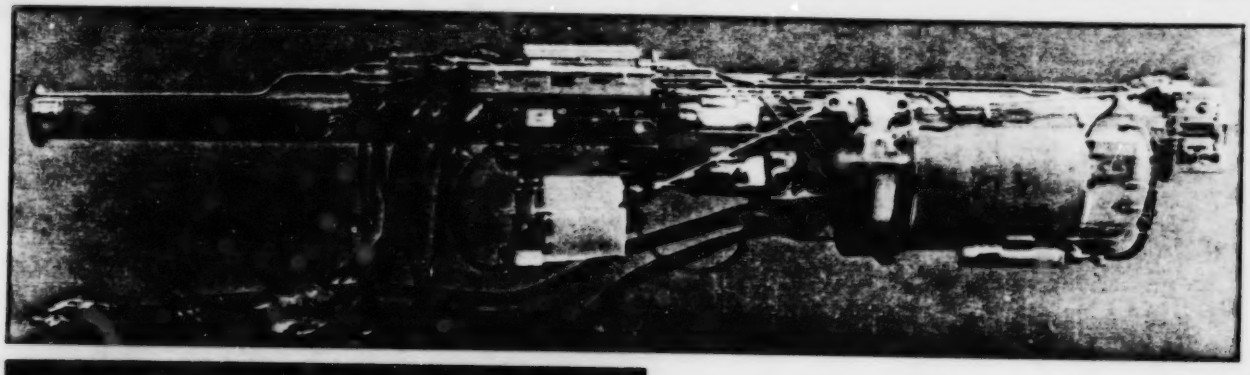

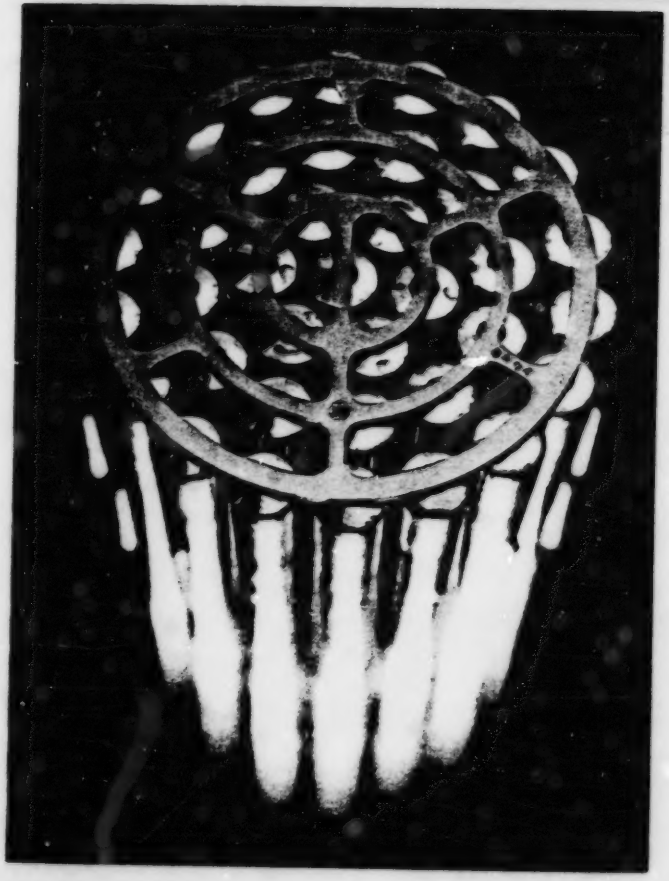

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The cover

1983 is the year Canada becomes the world's leading uranium producer. The photo is at the Denison Mines operations at Elliot Lake, Ontario.

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Message from the Chairman of CNA

Nineteen eighty-three is an important year in the life of the nuclear industry. It is a year in which the immediate severe economic problems confronting the industry contrast with some significant long-term opportunities based on existing over-capacity as well as on the successful commissioning of the 600 MWe CANDU reactors.

With the demand for electricity falling, in step with reduced economic activity, potential short-term markets for nuclear power plant sales, domestic and overseas, have faded. We have seen the inability of the best talents in the world, in government, in finance and in industry, to forecast even for the near term. In the past few months, the instability of world oil prices, responding to the reality of supply and demand, is another factor influencing decisions on future energy projects in Canada and abroad.

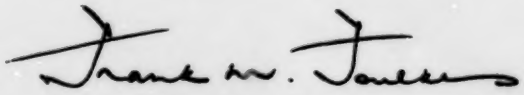
In this context, it is not surprising that the Canadian Nuclear Industry, after the rapid expansion in the 1970s, is faced with severe challenges to bridge a gap in orders during the early 1980s. While existing power stations will continue to run and will need a significant number of Canadians for their operation and servicing, I believe that current efforts by AECL, utilities and private industry will ensure the retention of the skills and organizations necessary for future nuclear power plant construction in Canada or overseas.

The existence of spare capacity for electrical generation places Canada in an enviable position in other respects. It provides the opportunity for Canada to pioneer industrial processes and domestic heating systems based upon plentiful and competitively priced electrical energy. Such developments could well contribute to Canada's own competitiveness in world markets in due course while revitalizing the nuclear industry.

Also on the positive side, the past year has seen the continued outstanding performance of the Ontario Hydro nuclear generating units on which the statistics are presented in this Yearbook. Even more significant to the nuclear industry, to Canada and to potential clients for CANDU, has been the completion of construction, commissioning and placing into operation of four standard 600 MWe units, in four widely different locations in the world, for clients of diverse cultural background, language and political structure. The early operations of the units at Point Lepreau 1 (New Brunswick), Gentilly 2 (Quebec), and Wolsung 1 (Korea) are beginning to demonstrate that the world record performances of CANDU units in Ontario can be repeated elsewhere. Also, Canada has shown that it has learned from earlier experience and can adapt to client requirements irrespective of location. At Wolsung, the construction period of 61 months is a record for CANDU units and in a world class for construction in exported reactor plants.

As breeder reactors and other advanced generation concepts recede further into the future, fission reactors of unit sizes with proven records of high performance will be purchased in the 1990s and well into the 21st century. Canada's outstanding technological development, the CANDU, will be in the marketplace.

This is the eighth edition of the Nuclear Canada Yearbook. Once again the contents have been expanded and it is my belief that this year's edition is the most complete source of reference yet produced on the kind of information those of us in the Nuclear Industry need on a day by day basis. In addition, the Yearbook will serve as a useful promotional vehicle for the industry. I would urge you to contribute to its success by drawing it to the attention of others and by offering suggestions as to how it can be further strengthened in the future.



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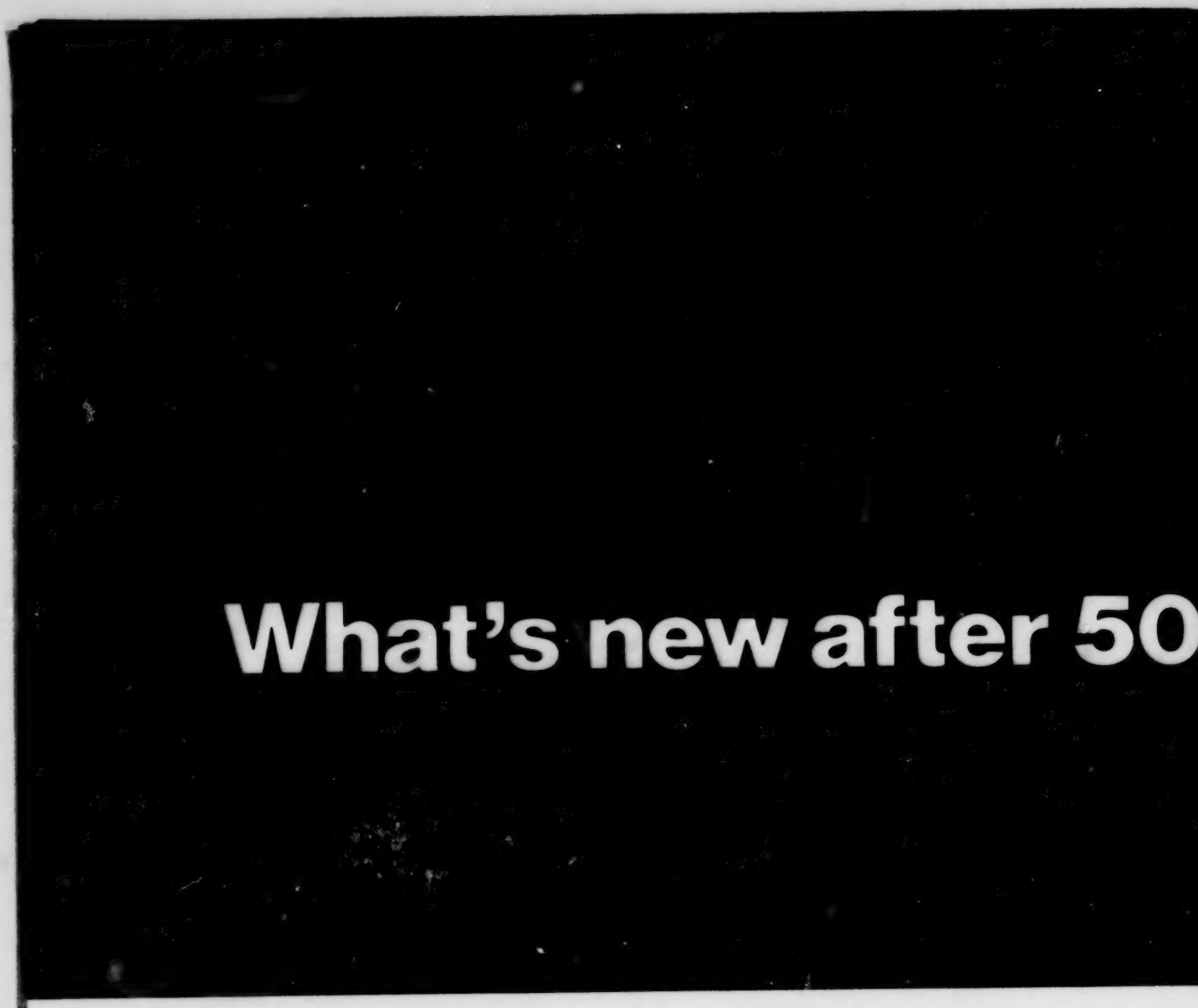
Experience
We have assumed major responsibilities on a number of nuclear projects; Gentilly 1 and the 600 MW CANDU station, Gentilly 2, in Québec, the 600 MW unit at Point Lepreau in New Brunswick as well as stations in India, Pakistan, Taiwan, Argentina, Korea and Romania.
We have also been involved in two heavy water production plants at Glace Bay and La Prade.



What's new after 50

After 50 years in the business, Eldorado is becoming one of the world's newest miners and processors of uranium.

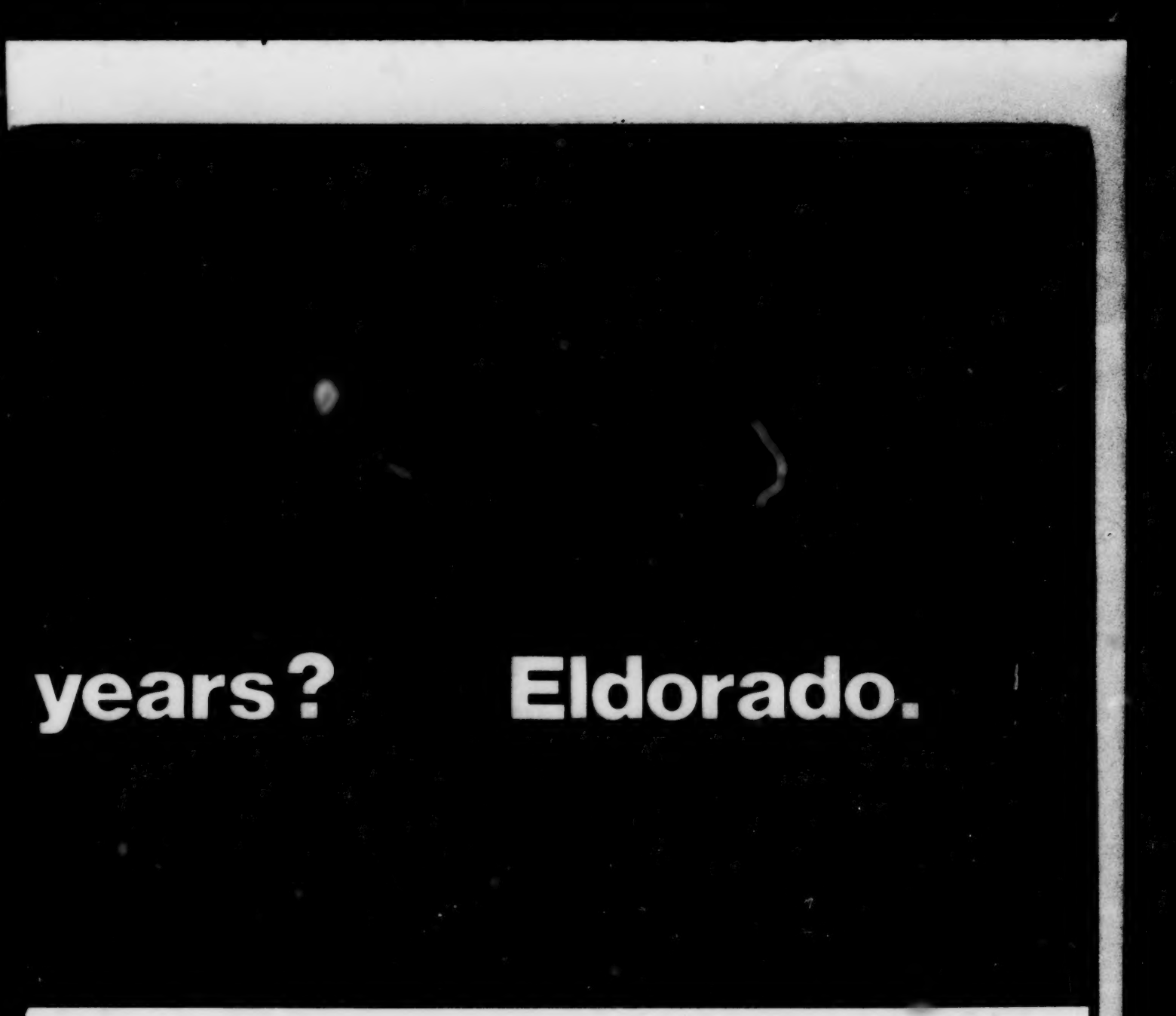
■ A new mine, with an annual production capacity of five million pounds of uranium concentrates, will be developed during the next 18 months to feed the Rabbit Lake mill in northern Saskatchewan.

■ A new refinery will be completed later this year in Blind River, Ontario, increasing our capacity to refine all of the uranium concentrates produced in Canada and some from other countries.

■ A new conversion plant in Port Hope, Ontario, is also nearing completion, expanding our capacity to convert refined uranium into uranium hexafluoride.

With the growth has come a need to change our organizational structure. Eldorado Nuclear Limited remains the parent company, but we now have two new subsidiaries:

■ Eldorado Resources Limited owns and services the three operating divisions — Eldor Mines which mines and mills uranium at Rabbit Lake in northern Saskatchewan; Fuel Services which includes the refinery at Blind River and the conversion facilities at Port Hope; and Metal Products which produces depleted uranium metal at Port Hope.



years? Eldorado.

■ Our second subsidiary, Eldor Resources Limited, holds a one-sixth interest in Canada's largest uranium mine and mill at Key Lake, Saskatchewan, which comes into production this year. Eldor Resources also holds Eldorado's exploration interests in uranium and other mineral properties.

If you would like a copy of our latest annual report, please write to:

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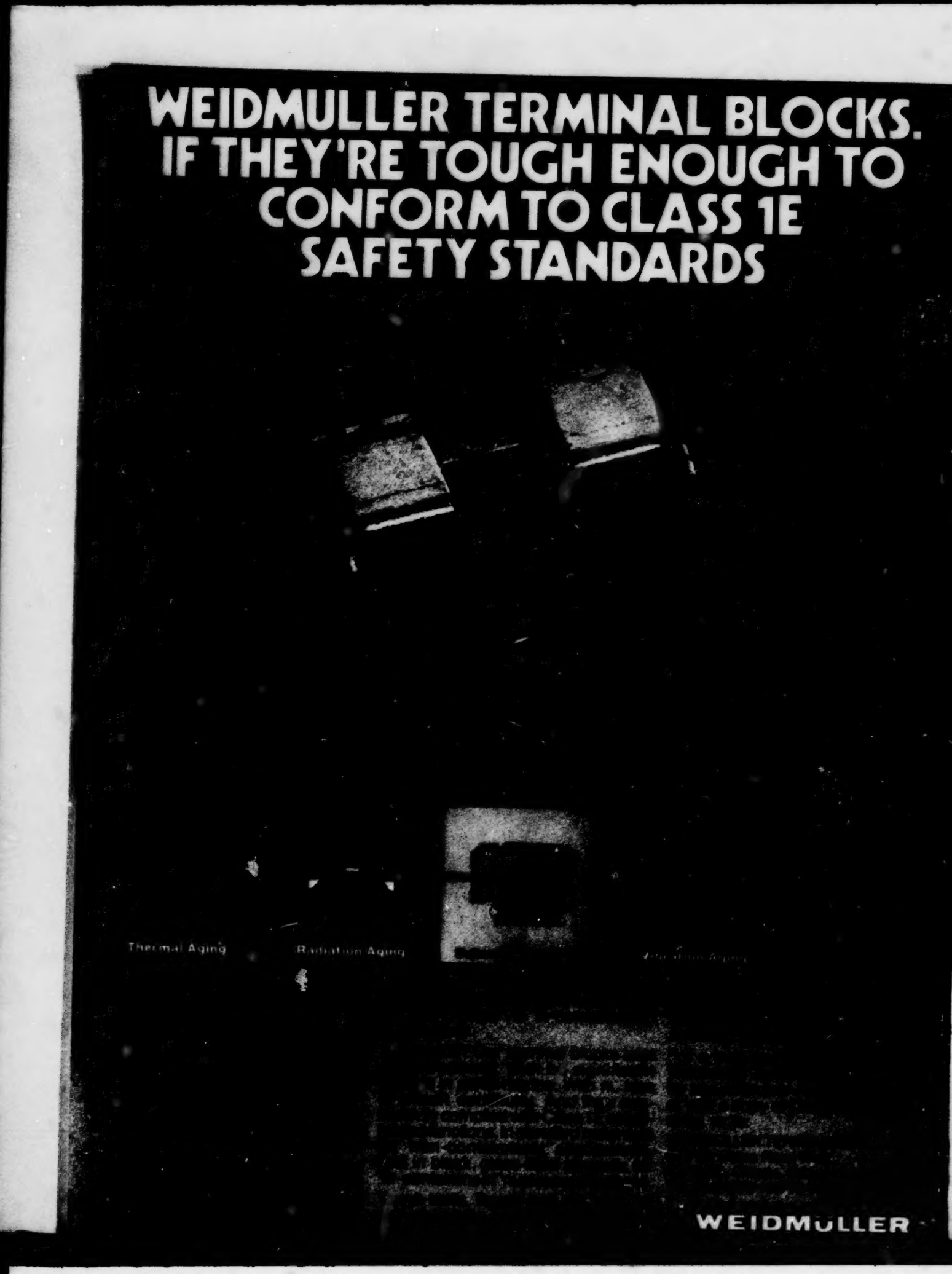

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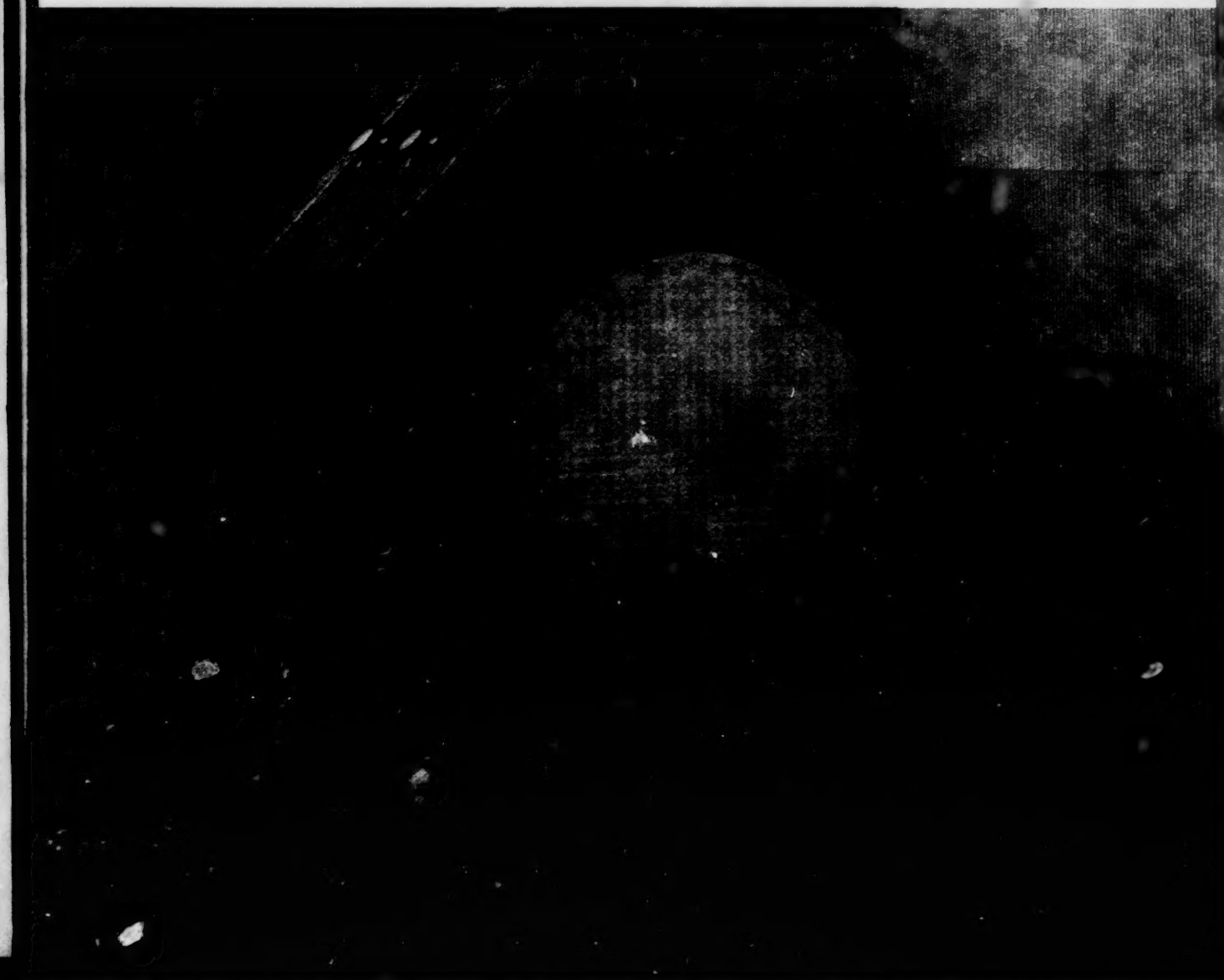
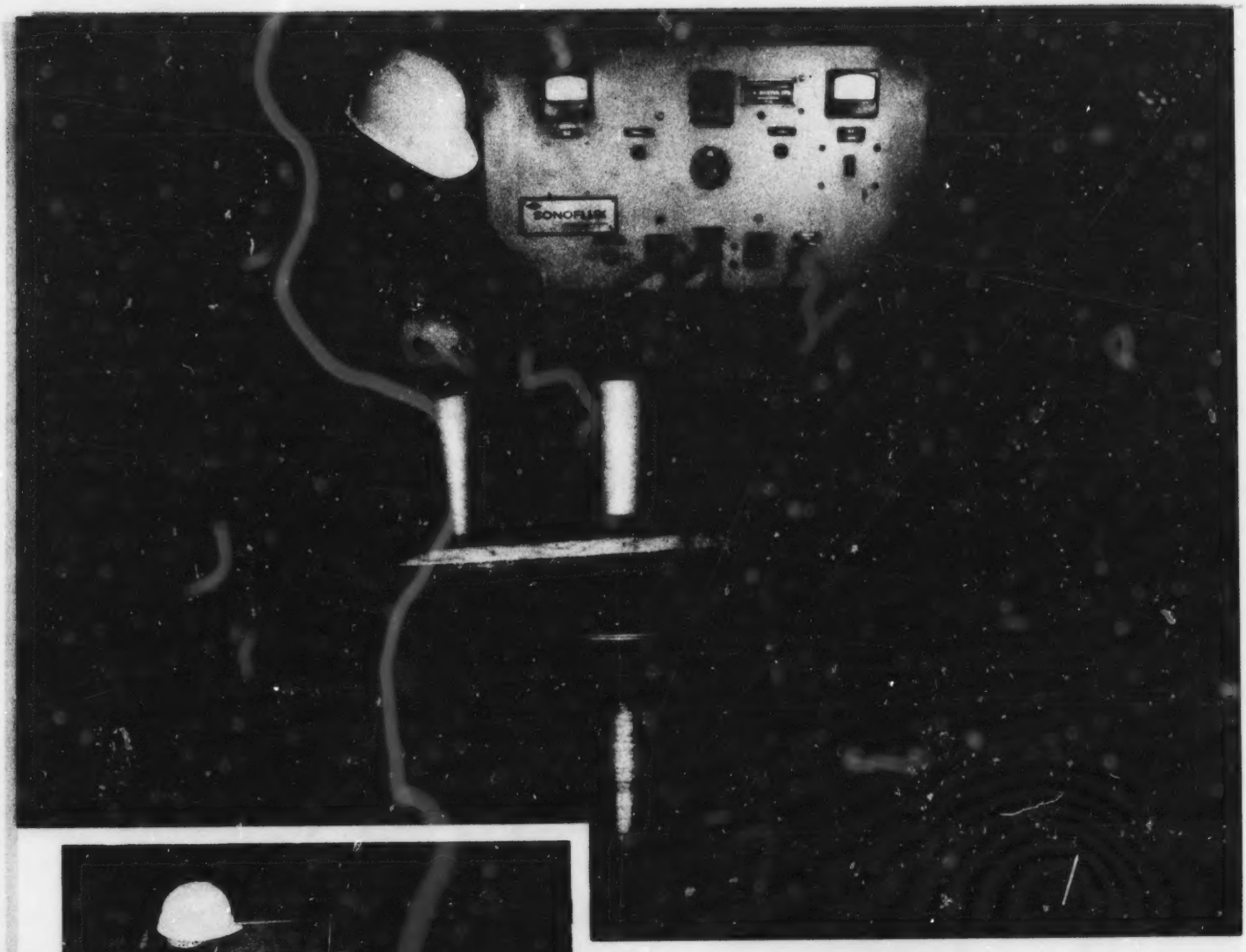
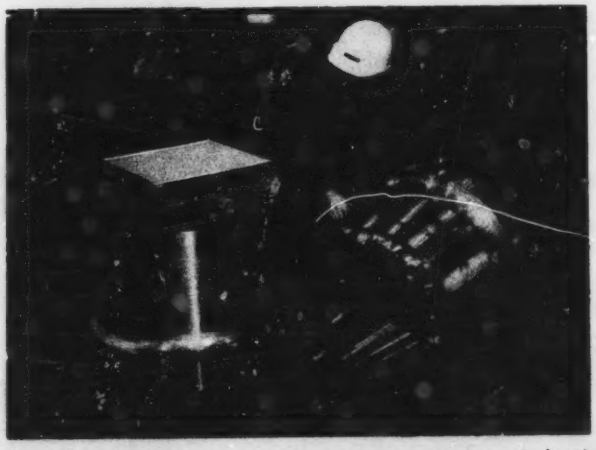




Immersion ultrasonic testing on seamless forged ring.



Ultrasonic examination on nuclear pressure vessel nozzle forging.

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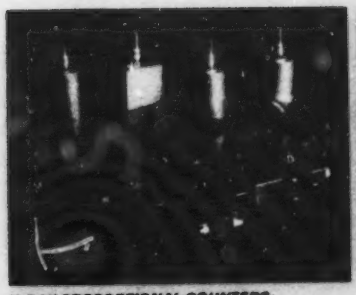

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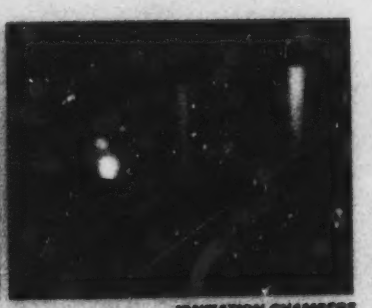

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A 1983 Overview of the Canadian Nuclear Scene

By N. Aspin, President,
Canadian Nuclear Association

In the field of nuclear energy Canada is unique. As a mid-sized industrial country Canada is becoming the world's leading producer of uranium and radionuclides for medicine and industry while at the same time its indigenous CANDU reactor system is the leading world performer.

With the exception of enrichment and reprocessing technologies which Canada has not found it necessary to develop, this country has made technical advances in all aspects of the nuclear fuel cycle. This is all the more significant in view of the entirely non-military nature of Canada's nuclear program.

This article highlights some of these developments from uranium prospecting to spent fuel management and indicates their present status.

Uranium prospecting technology

In the early days of uranium exploration success depended on the prospector finding a surface expression of the ore body usually with the help of a radiation detector. While there is, as yet, no single method for detecting uranium more than a few metres below ground, Canada has pioneered the development of a wide variety of sophisticated technologies which aid in the location of uranium ore bodies. These have been used with great success during the past decade in the discovery of many of the high grade ore bodies in Northern Saskatchewan.

The past year has seen expansion of the underground mining operations in Elliot Lake continued on schedule. Mine properties which had been closed in the early 1960's are being redeveloped to provide the required production to the end of the century and beyond. At the same time uranium mines in both Ontario and Saskatchewan have been closed due to high costs of production.

In Saskatchewan the high grade surface mining operations are being brought into production in an orderly fashion, though not as rapidly as had been initially anticipated. Later this year the large Key Lake mine will come into operation. These factors are contributing to the emergence of Canada as the world's leading uranium producer with

a 1983 forecast of 21.8 millions of pounds of U_3O_8*. This change in leadership has been accelerated by the dramatic decline in production in the US due to the closing of many mining operations having high operating costs.

*NUEXCO Analysis & Commentary, March 1983, #175, page 20.

The long-term outlook for Canadian uranium mining looks favourable. The higher cost uranium operations in Eastern Canada have the benefit of long term contractual markets while the high grade, lower cost Western uranium production should be competitive in almost any uranium market. These recent developments have taken place at a time of significant improvements in worker health and safety and better protection of the environment.

Threefold increase in refining

In order to keep pace with increasing uranium output Canada's uranium refining capacity is being expanded threefold. As noted elsewhere in this publication the next year should see the opening of Eldorado's new uranium hexafluoride plant at Port Hope and the completion of the UO_3 plant at Blind River. The refining program will include major improvements in pollution control and the recycling of former waste will produce saleable products for agriculture and industrial processes.

The author being interviewed by CBC TV during Nuclear Show '82 held in conjunction with the 1982 CNA/CNS International Conference in Toronto last June.

Increased fuel requirements

Canada's nuclear industry has made a significant contribution to the development of nuclear fuel. Natural uranium fuel used in the CANDU system has a remarkably low failure rate. Canada now has three companies involved in fuel fabrication with the addition of a New Brunswick facility. The long term prospects for the nuclear fuel industry are good since the number of nuclear electric generating stations in operation in Canada will double over the next decade.

Reactor sizes under consideration

The extraordinary performance record of the CANDU reactor system underlines the coming to full maturity of the pressurized heavy water reactor. At present Canada has essentially two sizes of commercial reactors. The first group comprises the 500 MWe multi unit station at Pickering in Ontario and the stand-alone 600 MWe units. The second reactor group consists of the 750 and 850 MWe multi unit stations at Bruce and Darlington respectively. Within the next 10 years there will be 12 reactors operating within each of the two groups.

There is an on-going evaluation of the design and economic feasibility of reactors of other sizes. These range from mini reactors based on the Slowpoke design for district heating and electricity generation in remote Northern regions through to reactors in the 200 to 300 MWe range which would be useful in developing countries with small electrical systems. Reactors in the 1000 MWe range for countries with large electrical grids are being considered. As the world need for further nuclear generating capacity develops it will be vital for Canada to have the appropriate size units to meet the market challenge.

Construction efficiency demonstrated

As CNA Chairman Frank Foulkes points out on page 3, Canada and Korea have constructed a 600 MWe station in the remarkably short period of five years. This is an enviable achievement considering that this is the first pressure tube reactor built by the Koreans and co-operation had to extend over such a vast geographical distance. Such successes have been further demonstrated in a recent European study by Unipede. This shows that Ontario Hydro's system of building four unit stations in a continuous development enables the unit cost of power to be brought below that of any European built reactor. When these lower construction costs are combined with the on-power refueling and the high capacity factors obtained by Ontario Hydro's CANDU plants the utility is able to produce power from uranium at a lower cost than any other nuclear power generating system.

Fuel loading at the Point Lepreau, New Brunswick 600 MW CANDU plant which became operational during the past year. Total fuel requirements for the reactor are being met by Saskatchewan Mining Development Corp.

Added to the CANDU performance achievements is the speed and relatively uneventful process by which the new 600 MWe units have all gone from first criticality up to full power during the past few months. That all four units are in different locations in the world and are being operated by power utilities having no previous experience with the CANDU reactor is cause for satisfaction.

Heavy water

A characteristic of all complex chemical process facilities is that it takes a few years for production to mature and be optimized.

Canada's heavy water plants have now reached the stage of maturity and the unit costs of production continue to drop. During this period of low demand, Canada is taking the opportunity to stockpile heavy water in anticipation of a future up-turn in reactor construction although, in the meantime, there is inevitably uncertainty concerning the future of the existing heavy water plants.

Waste management remains political

The Canadian program for high level waste management continues on schedule. With its emphasis on deep geological disposal in the old rocks of the Canadian shield drilling has been conducted in various types of plutons within the shield itself. In addition, construction continues on the underground research laboratory at Lac du Bonnet in Manitoba. Irradiated fuel is presently stored successfully on site at the generating stations in water-filled pools. Evaluation is continuing on above ground dry storage casks and it is possible that this will be an intermediate stage before final disposal of the irradiated material. Despite some public pressure to speed up this process the technical studies appear to be moving on a successful course towards completion at the end of the 1980's.

A new national organization called the Office of Low Level Waste Management, to deal with low level radioactive wastes, has been established within AECL. This is a welcome move considering the increased generation of low level waste by industry, hospitals, universities and the nuclear

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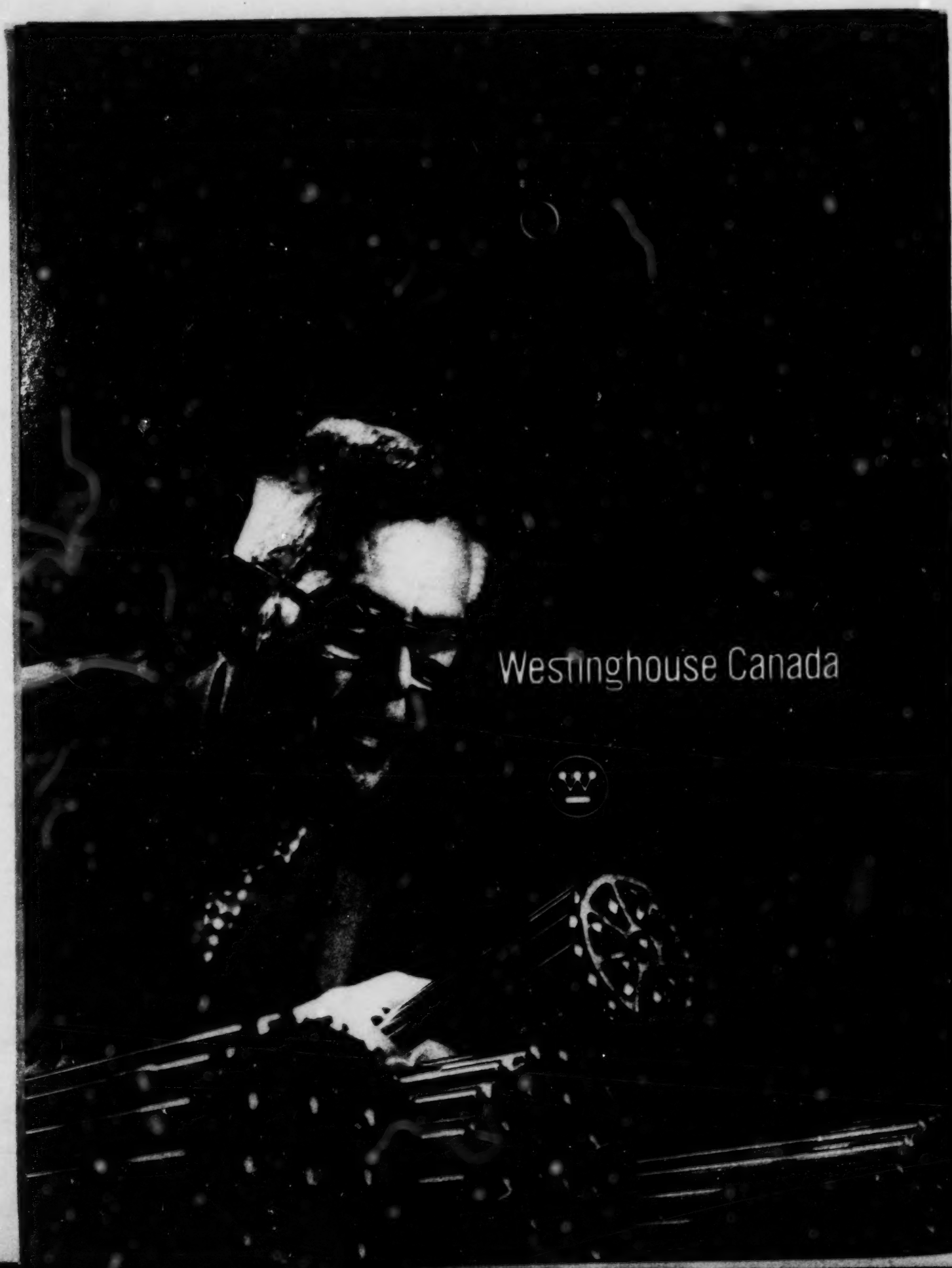

Westinghouse Canada

1983 OVERVIEW
(continued from page 13)

industry itself. It is hoped that this new agency will be able to deal effectively with some vexing historical problems which have developed into intransigent public and political issues. Many of these problems relate back to the disposal of radium wastes generated during World War II. The resolution of these historical problems is a necessary and important piece of housekeeping for the industry, and will go a long way to reduce the understandable public anxiety which has developed.

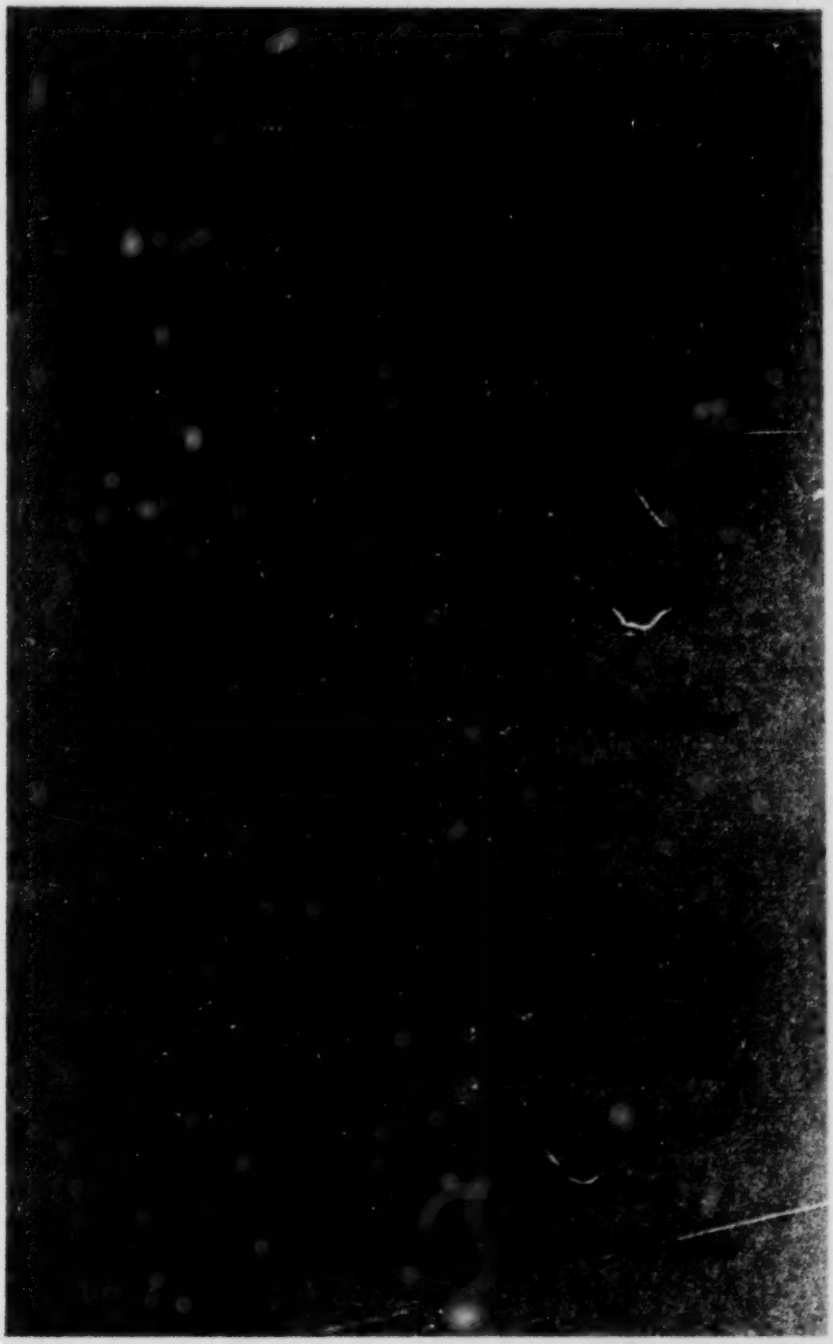
Important economic impact

The economic impact of the nuclear industry is important for Canada, as was shown by the CNA study published early last year and recently updated. The annual economic activity generated by this industry is in excess of $4 billion dollars with direct employment reaching almost 40,000 high skilled jobs as shown in table below. Since the statistical data are inevitably more than a year old they do not accurately reflect the economic downturn of the past year. Despite this, the industry remains remarkably resilient. The major areas of slow-down have been in uranium exploration, consulting engineering and CANDU manufacturing. In all the other areas employment and economic activity have been remarkably stable. Significant future opportunities lie in the area of supply and service to the operating nuclear stations, especially in decontamination, equipment retrofit and the deployment of remote handling technology. It is significant that Canadian expertise in decontamination is now being marketed abroad.

On a national scale there have been recent declines in apparent support for the nuclear power program which are somewhat surprising in view of the success and safety record of the program. However, in those regions of the country which have mining operations or uranium generated electricity the support for the nuclear power program remains high. As noted in the article on public perceptions superficial analysis of the decline in overall support suggests that it is related more to the poor performance of the economy, the present uncertainty in the world energy price and supply situation and the perceived linkage between nuclear electric power generation and military nuclear programs than to concern about nuclear energy per se. These sudden changes in public attitude continue to be a major concern for our industry.

	Manyears in 1980	1981
Uranium		
Exploration	500	400
Mining & milling	6,068	6,740
Refining	892	630
Fuel fabrication	649	649
	8,109	**8,419**
AECL	**7,512**	**8,021**
Utilities		
Ontario Hydro	12,578	14,578
Hydro Quebec	1,460	1,820
NBEPC	2,165	1,239
	16,203	**17,637**
Manufacturing	**5,400**	**4,700**
Consultants	**1,000**	**800**
Other R & D	**200**	**200**
Total	**38,424**	**39,777**

Employment in Canada's Nuclear Industry



Moral and ethical analysis

A significant development within the industry is the amount of attention given to broad social issues relating to the use of nuclear energy, especially in terms of

(continued on page 23)

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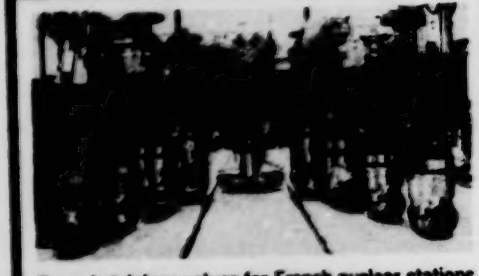

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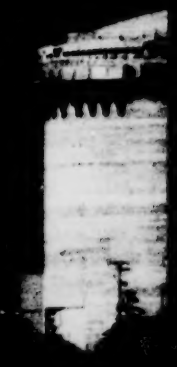

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CANDU: The Nucleus of an Industrial Strategy

Canada has the resources, human, natural and technological, to build a world-class industrial economy. The CANDU nuclear industry can help make it happen.

By John G. Melvin
Atomic Energy of Canada Limited Research Company

About a dozen nuclear units are operating in Canada, building a performance record unexcelled anywhere in the world while generating electricity at an economical cost. About a dozen more are under construction. Low-cost electricity, exploited to the full, is capable of powering a major portion of Canada's homes and factories, thus releasing our oil resources to provide mobile energy. These resources include the oil sands which, by themselves, would be able to provide our transportation fuel requirements almost indefinitely.

In the world energy scene, Canada stands out as different and almost unique, a land with oil for transportation, electricity for other uses and surplus natural gas for profitable export.

The energy opportunities facing Canada are almost beyond imagination and nuclear is a key component with a proven record of performance. In spite of the record and the opportunity, however, the Canadian nuclear industry is in the doldrums, facing some lean years and struggling to survive. Why? The immediate reason is the decline in the growth rate of demand for electricity, a decline that is attributed by some to conservation and by others to saturation of the market. The reason is neither of these but economic recession.

We have surplus electrical capacity for the same reason that we have surplus workers, the unemployed. The reason is economic recession.

Figure 1 shows that we have not been conserving electricity; if anything, the quantity of electricity used to produce a dollar of GNP has increased in recent years. In round numbers, we use one kilowatt-hour to produce a dollar's worth of goods and services. This was true before the oil crisis and since, through boom and bust; it is one of the few stable indicators, perhaps the only one, among the chaotic statistics that measure the performance of the economy.

It is not surprising that energy conservation efforts have had no measurable effect on electricity consumption because, until recently, electricity was a premium form of energy and was treated accordingly; it was expensive compared to oil and was used only where necessary and, characteristically, with high efficiency.

Until 1973, oil was the great equalizer; it was available anywhere in the world at the same low price, a few dollars per barrel, and was cheaper than any other form of energy, including electricity from prime hydraulic sites. Oil was treated accordingly; it was used lavishly, with little thought for efficiency because efficiency did not pay a return. One consequence is that there is fat in oil-burning systems, there is room for conservation. For this reason, oil conservation efforts in response to the oil shocks of the '70s have produced substantial savings. Thus, total energy consumption has declined, but electricity consumption has not.

Electricity is first and foremost a production tool, not a consumer good.

Promoters of the Conserver Society have pitched their message at the consumer level when attacking the use of electricity: turn off the lights and the TV, don't use electric toothbrushes, buy an energy efficient refrigerator, and so forth. Trivial pursuits. The domestic consumer uses only about one-quarter of our total electricity; industry and commerce use the rest, to produce goods and services. A person at work uses several times as much electricity as a person at home, which leads to an obvious conclusion: unemployment saves electricity. This conclusion has been amply and painfully demonstrated during the past two years and continues to be demonstrated today.

The industrial future is electrical and this offers Canada a competitive advantage in world markets.

An important consequence of the oil-price shocks of the '70s is that there is no longer a universal standard price for energy. In the days of cheap oil, industry tended to locate where the natural resources were, where labour was cheap, or where the major markets were situated. Energy price was not a factor except for specific operations such as aluminum smelting which gravitated to sources of low-cost electricity, where they produced ingot for export.

Oil no longer sets the global standard for energy cost; it has been displaced, at least in Canada, by electricity. This reversal of roles has two consequences: first, efficient use of energy is now important because the cost of energy has increased several-fold, and second, there is no longer a universal standard of energy cost. What this means is that a country able to provide energy at low cost relative to competitors thereby gains an economic advantage. Canada is such a country, by virtue of low-cost electricity. Electricity in Canada is not only cheaper than oil, but also cheaper than electricity and most other forms of energy in the industrial countries with which Canada competes for world markets.

The cost of electricity is low in this country because of the large base of

hydroelectric power which currently provides about 70% of our electricity, and because of the performance and economics of CANDU nuclear electricity, which will allow Canada to expand its electricity capacity to meet any foreseeable need without substantially increasing the cost of electrical energy. Electrically, Canada is unique because of its unbeatable combination of hydraulic and nuclear resources, both of which are economical and inflation-resistant. From now on, energy means electricity, not oil. The cost of electricity in Canada is not only low, but stable, thus providing a firm basis for energy planning in an otherwise uncertain economic environment.

Electricity is smart energy, able to do the work better, faster, more efficiently and at lower cost.

Electricity is primarily a production tool. It is a very sharp tool. Most industrial plants operating today were designed for the combustion-based world of the 1950s and '60s, when oil was universal and cheap. These plants are now obsolete, first because oil, or any other fuel, is no longer cheap, and second because the advance of technology has favoured electrical processes rather than those based on fire and smoke. While most of today's industrial processes depend on combustion, there are few if any operations that could not be done electrically. And done better. Whether the process involves mining, smelting, refining, metal-working, heating, cooling, evaporation or concentration, a variety of electrical processes is available and more are on the way.

These electrical processes have several general characteristics. They are energy-efficient, typically using one unit of electrical energy to replace 2-5 units of combustion energy. They permit larger throughput in smaller equipment. They offer fine control, because voltage and current can be measured precisely and changed instantly. They produce less pollution, because of the absence of combustion products. Most significant of all, electrical processes are readily automated; they are amenable to control by microprocessors and to participation by robots. An electricity-based industry is, almost by definition, a hi-tech industry.

A notion promoted by some economists is that the "smokestack industries" are no longer viable in the advanced countries and will relocate in unspecified third-world countries where labour is cheaper and, presumably, pollution is more acceptable. In other words, Canada should expect the demise of the iron and steel industries, along with non-ferrous metals smelting and an unspecified range of other major producers which will migrate to poorer and less fastidious regions. While this geographical solution to the problems facing these industries has the virtue of simplicity, there is little else to recommend it. The more likely solution is technological: the substitution of electricity for combustion, bringing energy costs under control, increasing productivity and eliminating the smokestacks. Few countries have such mineral wealth as Canada and fewer have low-cost electricity. To ignore the ore and export the associated jobs rather than exploiting the technological opportunity would be to choose third-rate status for the next generation of Canadians.

There are blue-collar workers and white-collar workers, but the steel-collar worker is the great equalizer.

The economists' dream, or nightmare, of the transformation of advanced countries into "information societies" by the migration of industry to third-world countries seems to assume that technology is static. Now that cheap energy, in the form of oil, is no longer available, comparative economic advantage is said to depend mainly on cheap labour or on something called "high technology". Cheap labour resides in the third world and, according to the economists, high technology means

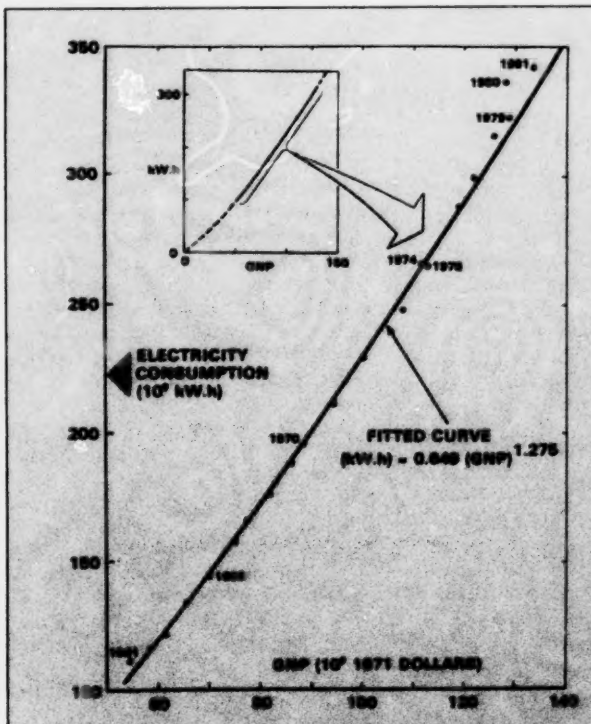

Fig. 1: Electricity Consumption versus Real GNP, Canada.

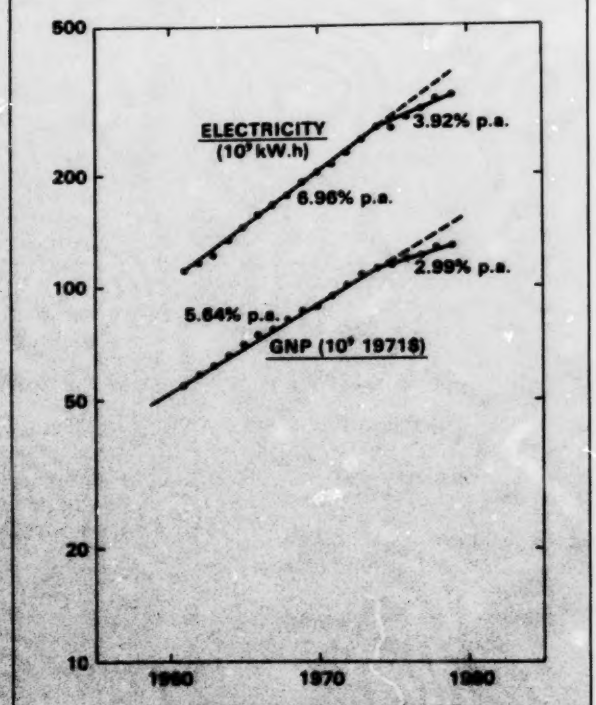

Fig. 2: Electricity Demand and GNP, Canada.

information processing. Hence, the information society. Unfortunately, in a society that processes information but not materials, most of the information is likely to be bad news.

Technology is not static and high technology is not limited to data processing, but includes data acquisition through an expanding range of sensing devices, data application through various controls and actuators, and materials processing and handling by a growing variety of techniques. The application of high technology to the production of goods and services has barely begun. Among the more dramatic advances is the robot which, although still in its infancy, has already had a major impact on the economics of manufacturing. In the past, Canadian workers found themselves in competition with low-paid Japanese workers; today the Canadian worker competes with Japanese robots, which are even lower paid. As the robot takes over the world's boring, dirty and dangerous jobs, he (she?) will establish a universal wage rate, said to be about four dollars per hour, thus eroding the comparative economic advantage of low-wage countries. As this revolution occurs, the competitive strength of each country will come to depend mainly on three things: natural resources, energy cost and technology. Canada has abundant resources and, by international standards, very low-cost electrical energy. The key is technology, which really means electrical process technology. The key is within our grasp.

The stark contrast between what is possible in this country and what is being planned deserves careful thought and demands action.

Electricity planning at all levels envisages a flat future of unchanging industrial technology and diminishing production. The projected two or three percent annual growth rates for electricity demand represent even slower economic growth in the next twenty years than in the past five. Why this dismal outlook and what action can be taken to change it?

The root cause is the global recession which is beyond the control of Canadians. While there is perhaps little scope for action to influence present or near-term economic conditions, there is at least the possibility of identifying a desirable future and planning to achieve it.

Since 1973 energy has been near the top of the policy agenda, but electricity, Canada's main hope for an industrial future, has been largely ignored. It has been ignored because both the public and the policy makers see electricity as a premium energy form with a saturated market. The economist sees in his statistics that electrical energy has certain narrow uses — lighting, motive power, communication — and remains unaware of its potential role as energy workhorse. The reversal of roles between electricity and oil, with the latter now being the premium, special-purpose energy form, has gone largely unrecognized.

Has the Canadian nuclear industry been selling the product, or has it been asleep at the switch?

Canada's unique opportunities in industrial electrification have not yet begun to influence energy policy or industrial strategy. How can this be? It is due in part to the failure of the nuclear industry to sell its product. Certainly there has been a concerted effort to sell reactors, but the reactor is not the product. The product is electricity: the reactor is merely the factory in which it is produced. There is little hope of selling factories when the market for their products is perceived to be saturated.

Some isolated examples suggest that the nuclear industry, far from selling the product, is not even aware of the present and future significance of electricity. How many CNA member firms burn fuel to heat metal although electrical heating would be more economical? How many burn fuel to raise process steam, while off-peak electric boilers offer fast payback? Are there uranium mines that burn fuel to heat ventilation air while electric heating might offer large savings?

There is a problem of awareness. The perception of electricity as expensive energy lingers on, reinforced by policies and practices in other countries which, unlike Canada, are burdened with high electricity costs.

To hasten the recovery of the Canadian nuclear industry and of the economy in general, one action at least is obvious: sell electricity to plug into the future.

Figure 2 characterizes two levels of Canadian economic performance, one healthy and the other stagnant, with an abrupt transition from the former to the latter in 1974. Current forecasts of electricity demand fall below the slow-growth level of Figure 2. Moderate economic growth, say a four percent annual expansion of real GNP, implies annual growth of at least five percent in electricity demand, doubling our electricity needs before the year 2000.

If Canadians plan to be something other than economic invalids, the important question is not whether more nuclear-electric units will be needed in this century, but whether we will be able to meet the demand in the 1990s.

All the elements needed to build a prosperous Canadian economy are at hand. All, that is, except awareness of what is possible for this most fortunate of countries. ■

References

1. This article is based on three reports published by Atomic Energy of Canada Limited:
   - "Electricity/Oil Substitution", AECL-7067, 1980 September
   - "Electricity and the Canadian Economy, AECL-7501, 1981 October
   - "Industrial Electrification: An Opportunity for Canada", AECL-7985, 1983 March.

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moral and ethical analysis. Pioneer work done by the nuclear industry in this area will have significant fall-out into other industries.

Success in other areas

Canada's long standing programs in the use of radionuclides in medicine for diagnosis and treatment and the use of intense radiation sources for the sterilization of food and pharmaceutical materials continues to enjoy commercial success. For example, Canada supplies about 65% of all the radioisotopes used worldwide each year. About one million patients receive radiation therapy from equipment produced in Canada and it is estimated that over 11 million years of life have been added through these treatments. But now there is reason to believe we are on the threshold of major developments in the use of food irradiation as a means of preservation. The implications of this are significant especially since food spoilage is a serious problem in some parts of the world where distribution systems are inadequate. The process is now being strongly supported by the World Health Organization which has reached the conclusion that radiation treatment of any food product is absolutely safe up to relatively high radiation doses. Canada is in a strong position to contribute in these areas of basic human need.

There are also potentially promising and challenging opportunities in the solution of ecological problems through the use of radiation in the treatment of sewage.

In summary Canada's nuclear industry has a basic maturity and strength across the whole nuclear fuel cycle which will allow it to come through this difficult world recession in a lean and strong position thus enabling it to move ahead as the world economy recovers. ■

Ultrasonic examination on nuclear pressure vessel nozzle forging.

World review of the past year

An increasing contribution by nuclear electricity in most regions but a long wait ahead for major new orders.

By Simon Rippon

With the industrial world in deep recession and virtually static growth in energy consumption, nuclear energy is still increasing its contribution in the electrical sector in most regions of the world. This is particularly noticeable in figures for the European Economic Community for 1982 which indicate an 11 percent increase in production from nuclear energy while other sources showed a decline of 1 percent.

Unlike the previous two years when substantial increases in nuclear generation were almost entirely attributable to the rapid progress of the French program, it was the start of regular production from plants in other countries which produced the main increase in 1982. Several plants which did not quite make it in 1982 will add to the increasing trend in nuclear production in the coming year.

Japan and the United States each had two new plants entering commercial operation during the year. In Japan the increase in nuclear production was around 19% taking the contribution of electricity production to just under 20% and in the U.S. a 2.7% increase in nuclear production raised the contribution to 13%.

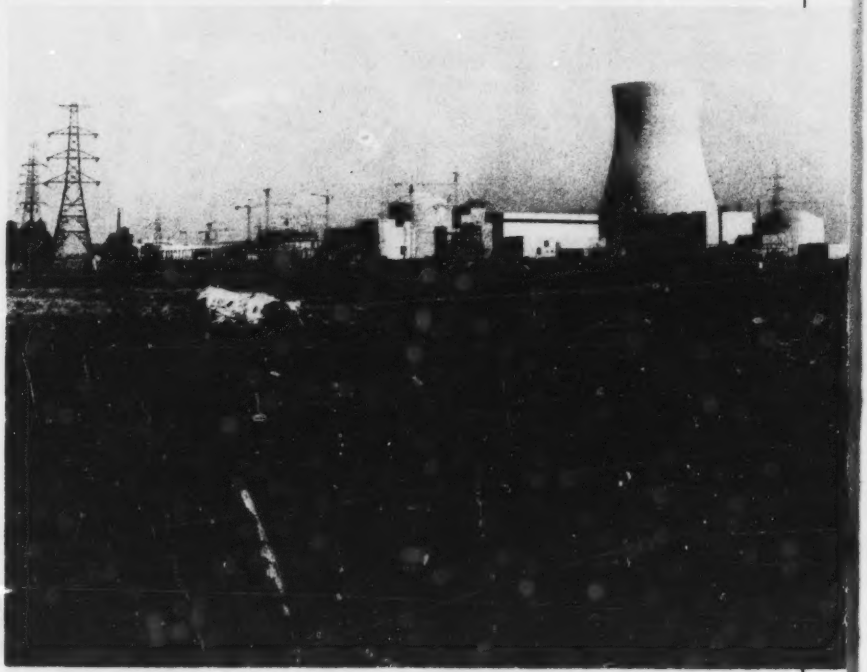
These figures, however, present little joy to the nuclear industry for everybody recognises that, with the exception of France, the plants currently coming into production represent the end of ordering that took place in the 1960's and early 1970's. The pattern of the past few years has been for cancellations and deferrals of projects in the U.S. to exceed the rate of orders for new projects in the rest of the world — including France. The prospects for new projects have improved slightly in Japan, and possibly also in the Federal Republic of Germany, but the delays associated with licensing procedures are now such that no plant on which construction has not already started is likely to make a contribution to production before 1990. Thus, even if the increasing production of low cost nuclear electricity starts to produce the long awaited turn around in attitudes to nuclear power, it will be a long time before any renewal of ordering could produce tangible results.

Belgium benefiting

Two new 900 MWe plants, Doel 3 and Tihange 2, were put into operation during the last half of 1982 in Belgium and were generating at full power by the end of the year. These more than double the country's nuclear generating capacity which was already supplying over 25% of electricity. Since 1975, when the earlier plants started to come on line, the electricity tariff for industrial users in Belgium has moved from being the highest among EEC countries to the second lowest after France. With the new capacity coming on line the Belgian Supervisory Committee for Electricity and Gas is calling for a reduction in tariffs in the coming year as a direct result of cheaper production costs from nuclear power.

These favorable developments have certainly been helped by the good performance that the Belgian utilities get from their plants. The two 390 MWe units at Doel have clocked up some 15 reactor years of operation with an average capacity factor of 78% while the 870 MWe unit at Tihange has recorded 7 years of operation at an average of 73% capacity factor. If similar good performance is obtained from the two newly-commissioned plants and two further 980 MWe units due to come on line in 1985, Belgium may be providing the most striking example of the benefits of nuclear electricity generation by the second half of the decade.

Belgium has nevertheless gone through a period of hesitation on follow-up orders and has been subjected to a protracted government review of energy and nuclear policy culminating in a series of commission hearings and a parliamentary debate during 1982. The outcome has set a generally favorable climate for the ordering of a further one or two 1000 MWe nuclear units provided that projections of load growth can demonstrate a clear need.



The 4-unit Doel site in Belgium where nuclear electricity accounts for over 25% output.

Different for the Danes and Dutch

The other EEC countries of comparable size to Belgium have held back from making a commitment to nuclear power and are seeing a very different situation. In both Denmark and the Netherlands electricity prices have been rising sharply despite, in the case of Denmark, a substantial program of conversion of oil fired plant to coal burning. But in both countries there has been a political shift to the right and there are some signs that this may provide a more favorable climate for long-delayed construction decisions that utilities have been urging for many years.

In Denmark an impressive program of geological investigation of salt domes — of which there is quite an abundance in Denmark — was completed during 1982 and has identified suitable options for final disposal of high level radioactive waste. This study is one of three called for by the previous government before it would even consider plans for nuclear plant construction. The other studies on the economics and safety of nuclear power plants should leave the way clear for a parliamentary vote and a referendum, possibly in 1983. A satisfactory outcome could lead to Denmark's first nuclear power plant coming into operation in the mid-1990s.

The Dutch are in the middle of a two year public discussion period of plans, first put forward in 1974, for the construction of three 1000 MWe nuclear power plants to add to the two small plants already operating. The discussion is due to be completed in October 1983 after which the government is committed to a decision. While the climate of public opinion on this issue is still distinctly negative, there is growing recognition of the heavy dependence on oil and natural gas for electricity production and the likelihood of this putting Dutch industry at a competitive disadvantage relative to other European countries.

France still forging ahead

There has been some scaling down of the previously projected rate of ordering of nuclear plants in France in response to lower projections of future growth in energy demand, but in any comparison with other countries the continuing French program is impressively large. Following the new Socialist government's review of the energy program at the end of 1981 decisions were announced to order six plants in the 1982-83 period — one 900 MWe and the rest 1300 MWe — instead of nine units as scheduled under the previous administration. At the same time the freeze on work at six construction sites, imposed in the summer of 1981 pending conclusion of the energy debate, was lifted.

There are further reports of falling forecasts of growth in energy demand and the possibility this might call for a reduction in the nuclear construction program. These projections will not affect the 1982-83 orders, however, but will influence the planning to 1988. Forecast figures for electricity production are 305 TWh for 1985 compared with the previous estimate of 308 to 334 TWh in 1985 and 345 to 367 TWh instead of 360 to 415 TWh for 1990. The report to government containing these projections makes a strong recommendation to compensate for the lower projected energy and electricity demand by reducing the planned increase in coal burning rather than reducing the nuclear program.

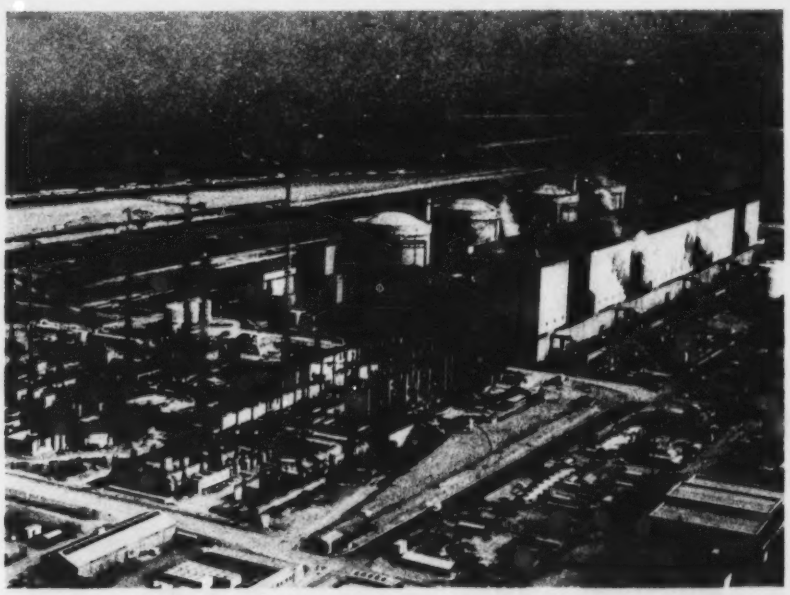
Problems have prevented Electricité de France from making any significant improvement in 1982 on the impressive 38.6% contribution from nuclear electricity in 1981 despite two new plants coming on line. Average capacity factor was down from 63% to 58% due to three main reasons: seven units — compared with four in 1981 — had to be taken off line for exhaustive checkups which are required after the first eighteen months of operation; the output from two PWRs at Saint Laurent was limited by a problem with the moisture separators after the steam reheaters on the turbine system; and a generic problem was encountered with the locating pins of control rod guide tubes. The last of these problems has been the most serious, accounting for the loss of the equivalent of one year's operation from a 900 MWe PWR, because it was necessary to change all 60 control rod guide tubes on the first three reactors — Fessenheim 1 and Bugey 2 & 4. A faster method, involving about six weeks work, has now been devised for remotely replacing just the defective locating pins. This will be used during refuelling outages over the next two years for the remaining 20 reactors which have to be modified.

The previously excellent operating performance of France's fast reactors has also been marred slightly during the past year, first with a minor leak in the sodium coolant circuit of the 40 MWth Rapsodie experimental reactor and then with steam generator leaks on the 250 MWe Phenix prototype reactor. As there were only two years of experimental work outstanding for Rapsodie it has been decided to close the plant. The likelihood of leaks occurring on the Phenix steam generators after many years of reliable operation had been anticipated but occurred before plans for phased replacement of tubes could be implemented.

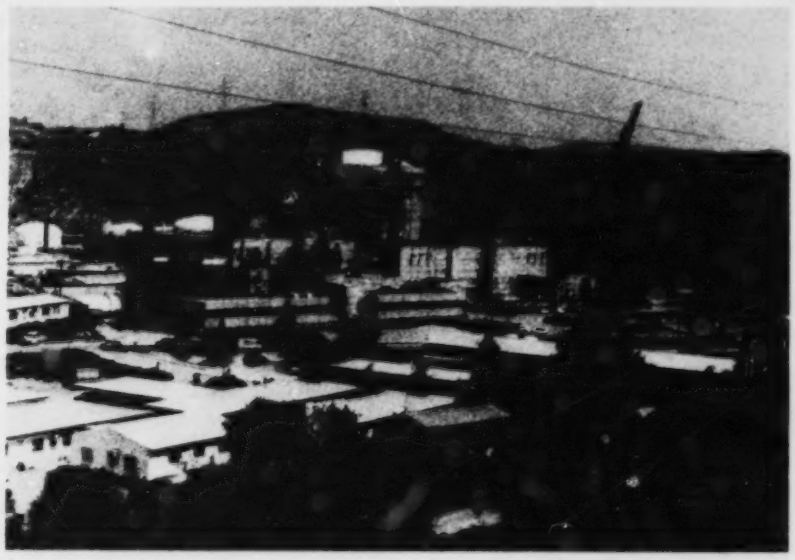
Construction on the 1200 MWe Super Phenix plant continues to make excellent progress at Creys Malville despite damage by extremists. Start-up is now likely in mid-1984 which represents an 89 month construction time compared with the original estimate of 7[illegible] months.

Green in Germany

The past year has seen a growth in support in Germany for the Green environmental party — passionately opposed to nuclear power — to the



In France some 39% of electricity is nuclear generated. Above is the six 910MW unit Gravelines plant on the north coast.



Construction setbacks have plagued Spain's nuclear program. Above, the 800 MW Asco 1 plant at Tarragama.

extent that they now have minority representation in a number of state parliaments. But green lights of a more positive kind have also been switched on for a number of nuclear projects which had been blocked since the mid-1970s. The change from a Social Democrat to Christian Democrat government is likely to be favorable to the nuclear power program.

During 1982 the first partial construction permits for three 1300 MWe PWR plants were issued setting in motion a new "convoy" system for licensing of standardized plants for different utilities.

The project at Brockdorf, which already had a construction permit but which had encountered many legal obstructions, finally got under way. During the year legal obstacles were also finally removed from the Whyl project. Brockdorf and Whyl have been symbols of opposition to nuclear power in Germany attracting many demonstrations and, in the case of Brockdorf, a great deal of political in-fighting in the city government of Hamburg. The nuclear industry has no illusions about disappearance of opposition to the projects but by moving into the construction phase they have at least established that the cumbersome legal process can eventually come to the right decision.

One new 1300 MWe plant at Grafenrheinfeld entered commercial service during 1982 bringing the installed nuclear capacity in Germany to 9855 MWe supplying about 20 percent of the country's electricity. A further eleven units are at various stages of construction and will raise the nuclear capacity to 21 855 MWe by 1988 with the new convoy projects.

The issue of spent fuel is still a cause of concern which has to be resolved by 1985 if new operating licenses are to be issued after that date. There is a need to provide reprocessing capacity, either in the form of contracts with foreign organizations or with a new domestic plant, for at least seven years forward arisings of spent fuel as currently required by German law. A so-called "demonstration" reprocessing plant with a capacity of around 350 tonne/yr was the compromise suggestion arrived at after rejection, for political reasons, of the proposal for a 1400 tonne/yr plant at Gorleben. Accordingly, the German Reprocessing Company (DWK) has been searching for sites in a number of states and initiating licensing procedures. Applications are being made for sites in Bavaria and Lower Saxony where the political climate is generally more favorable for getting the necessary first partial construction permit by 1985.

Another issue that has gone from crisis to crisis during the past two years is that of funding for the completion of the two advanced reactor prototype projects in Germany — the SNR 300 fast reactor at Kalkar and the THTR 300 high temperature reactor at Schmehausen. The moving target of ever more demanding licensing requirements has pushed the completion date for these two projects back to 1986 and 1984, respectively, from the original 1981 and 1978 with huge attendant increases in the cost. An important development during the year has been the conclusion of a fact finding commission set up by the federal parliament that the safety of the SNR 300 is at least as good as that of commercial light water reactors in Germany. This led to a recommendation to the parliament, accepted by a vote in December, that they should relinquish their right to veto operation of the plant once completed.

Italy — this year perhaps

Yet another change of Italian government during 1982 was not a severe setback to a new nuclear construction program as previous changes. This is because the former Industry Minister, Fillipo Maria Pandolfi, has retained his post under the new government. He has probably done more than his predecessors to get positive action on the national energy plan (PEN). The latest version of PEN calls for a start on the construction of 6000 MWe of nuclear capacity in the form of twin 1000 MWe PWR units at three sites in the regions of Lombardy, Piedmont and Apulia, as well as 6000 MWe of coal fired capacity.

Beyond these first six units, which it is hoped will come on line in the early 1990s, the PEN envisages further two-unit nuclear plants in the Veneto and Tuscany regions and one-unit plants for Campania (probably near the Garigliano BWR plant which has now been closed down), Basilicata, Sicily and, possibly, Umbria instead of one of the coal fired plants. Consideration is also being given to the possibility of further units at the Caorso site where the BWR plant is now operating at its full power of 860 MWe and at Montalto di Castro where two 1000 MWe BWRs are currently the only commercial power station projects in construction.

It has been noted that the use of standard PWR units, built under a Westinghouse license, that have been prescribed by PEN for the next 6000 MWe of orders, is not a rigid requirement for the future and it is likely that the licensing arrangement with General Electric will be kept alive for possible future BWRs.

Socialists in Spain

A new Socialist government came to power in Spain at the end of 1982 with declarations that it would cut back the nuclear power plant construction program from the proposed 11 500 MWe of installed capacity by 1987 to a mere 7500 by 1990. Projects already underway which are threatened include the two 975 MWe BWRs at Valdecaballeros, two 1000 MWe PWRs at Trillo, and a 960 MWe PWR alongside the operating gas-cooled reactor at Vandellos. Also 1000 MWe PWR projects which have preliminary licenses

for Sayago, Vandellos 3 and Regodola are unlikely to get approvals for start of construction. But the industry is fighting back and arguing the case for the need for these plants that will arise if there is any recovery from the worldwide recession, pointing to lost jobs and the large cost of abandoning projects in construction. At the end of 1982 a statement from the new Minister of Industry and Energy indicated that the provisions of the Socialist Party for a limit of 7500 MWe of nuclear capacity "are flexible" and the exact quantity of nuclear plant that will be needed has yet to be determined.

It has not been a happy year for the first six 930 MWe units of Spain's current program of construction. Following a further atrocity by the extremist Basque group, ETA, it has not been possible to get a resumption of work at the Lemoniz site. Operational control has now been handed over to the regional Basque government and there might be a resumption of work in the coming year. The first unit at Almaraz, which was started up in 1981, encountered the problem of vibration in the pre-heater section of its steam generators and has been limited to 50% power level pending modifications. The first unit at Asco only achieved first criticality at the end of 1982 after overcoming efforts by local councils to block operation. Similar action by the local councils to prevent start up of the second Asco unit in 1984 has only been overcome by going to the country's Supreme Court for a ruling on the national importance of the project.

Socialists in Sweden

The return of a Socialist government in Sweden might have been expected to improve the political climate for nuclear power. The country's nuclear power program is restricted to twelve reactors with the undertaking to phase out nuclear power by 2010. It was an earlier Socialist government that had formulated the ambitious pre-1975 program which stimulated some five years of agonising public debate over the nuclear option. But attitudes have changed considerably and the new government — and in particular the new Energy Minister, Brigitta Dahl — are, for the time being, sticking to the position that they will abide by the conclusion of the 1980 referendum. The subject is not likely to become a live issue until the Energy Committee set up by the previous government to investigate fully the implications of phasing out nuclear plants, produces its conclusions later this year.

The best hope is for the operating plants to prove indispensable. With nine of the twelve reactors now in commercial operation, nuclear power is currently accounting for over 36% of the country's electricity and with the start up of the tenth reactor this year and the last two in 1985, the proportion will rise to nearly 50%. Despite the need to extend annual shut downs for five units by six to ten weeks for special repairs, the Swedish BWRs have continued to operate very well with capacity factors above the world average for nuclear plants and in one case over 90%. The second of three PWR units at Ringhals has, however, encountered the problem of vibration damage to tubes in the pre-heater section of steam generators and has been limited to a power output of 50%. An improved feedwater diffuser has been developed to overcome the problem. A similar modification is being made to the Ringhals 4 unit — the third PWR at the site — which achieved first criticality in May 1982 but is not now expected to start producing power until early 1983.

Swiss dilemma

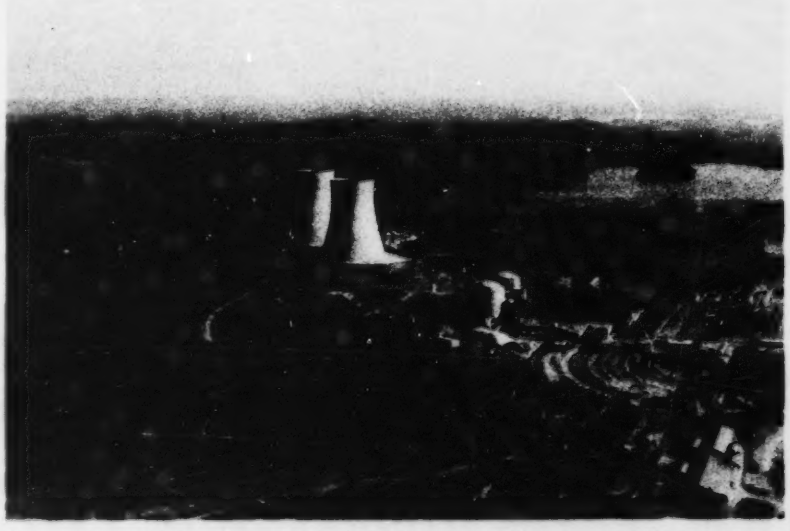
The proposal to build a BWR power station at Kaiseraugst near Basle was, in the late 1960s, one of the first European nuclear projects to attract public opposition. Today it is still no nearer to being built and, whether the Swiss utilities pursue or abandon the project, it threatens future development of nuclear power. As required by the revised law following a 1980 nuclear referendum, a case has been made for additional nuclear capacity to the Federal Council and accordingly a general license for construction of Kaiseraugst was issued in March 1982. But before a construction permit can be issued this general license must be approved by both houses of parliament. Knowing the passionate opposition to the project in the Basle region there is no eagerness to hold the necessary debates. One way out might have been to substitute the 1140 MWe BWR proposed for Graben near Berne as the next nuclear plant, but the local government of Berne, while generally less hostile to nuclear power than Basle, has indicated that it will do everything in its power to oppose such a substitution.

The situation is further complicated by a new anti-nuclear initiative which obtained enough signatures to require a referendum. Unlike the previous unsuccessful initiative which sought to stop all nuclear power, the new initiative is cleverly worded to seek only to halt all nuclear power construction after Leibstadt, the 940 MWe BWR due for completion next year. Thus the effort to stop the unpopular Kaiseraugst project could become the focal point of the initiative campaign and, if the nuclear opponents were to win this time, it would also block further projects such as Graben.

Perhaps the most bewildering aspect of public opposition to nuclear power in Switzerland is that it persists despite the fact that no country in the world is producing better performance from light water reactors. The four operating plants have recorded an average capacity factor of around 85% in recent years and are supplying some 28% of the country's electricity.

U.K. preoccupied with PWR

A large part of the nuclear community in the United Kingdom spent 1982 getting ready for the public inquiry, which started in January this year, into the



Last year saw 18 projects cancelled and 28 delayed in the US. However, TVA's second unit at Sequoyah, shown here, was one of six units to receive operating licenses.

building of a single 1100 MWe PWR at Sizewell B. This apparently disproportionate amount of effort stems largely from the fact that the inquiry will not only be the most public examination yet of the complex case for changing from gas-cooled reactors to light water reactors, but will also examine all the issues of nuclear power.

The Central Electricity Generating Board (CEGB) in the statement of its case for building Sizewell B -- is not pressing the need for megawatts of additional capacity. It is accepted that growth in demand has flattened so dramatically in recent years that it would not matter much if the proposed plant were to come on line as scheduled in 1991 or later when the first generation nuclear plants will be due for replacement. The primary argument is that the economic case, even for this one-off PWR, is so compelling it is an investment that cannot be ignored. This is true even if it meant early retirement of coal fired generating capacity although continued support for the domestic mining industry is still a sensitive political issue. A further incentive for the CEGB is to reduce the 80% dominance of coal in its mix of fuels.

While attention is focussed on Sizewell B, there is still a need for work on the existing program of gas-cooled reactors, especially the advanced gas-cooled reactors (AGR) which will be responsible for most production to the turn of the century. It had been hoped that Dungeness B, Hartlepool and Heysham A AGRs would start to produce electricity during 1982, but the need for further modifications to the complex fuel stringers came to light from engineering rig tests. Despite the serious delays that these projects have suffered there is still confidence that they will ultimately produce reliable and economic electricity. This is supported by operating experience from the AGRs at Hinkley Point B and Hunterston B which are finally starting to make use of their on-load fuelling capability to improve availability. Meanwhile construction of two more AGR power stations at Heysham B and Torness, which was started in 1980, appears to be progressing well and these projects may finally demonstrate the original promise of the AGR system.

There is growing apprehension that much of the pioneering work done in the U.K. on fast reactor development is being lost because of lack of a firm commitment to build a commercial sized demonstration project — the 1200 MWe CDFR. Secretary of State for Energy, Nigel Lawson, reaffirmed a commitment to a substantial fast reactor development program because of the long term prospects of the system and the security of supply that it offers. But due to the current low price of uranium it was not possible to see a case for commercial ordering of fast reactors before early in the next century. Notable by its absence was any mention of the CDFR or whether the country should press ahead with such a project in order to be ready for commercial ordering of follow-on units by the turn of the century. It called on the new Chairman of the Atomic Energy Authority, Sir Peter Hirsch, to draw up a continuing fast reactor development program taking into account the longer timescale for commercial exploitation. The statement also urges further exploration of collaboration with other countries and the best hope now is that an international project based on the CDFR, or a comparable large demonstration reactor, will materialize.

U.S. utilities unhappy

With 18 nuclear power plant projects cancelled and some 28 units delayed, 1982 was at first sight one of the worst in the history of the U.S. nuclear industry. While there is little prospect of early recovery, there are some encouraging signs and the much publicised cancellations probably represent the end of utility adjustment to the wave of over ordering in the late 1960s and early 1970s.

1982 saw the issue of six operating licenses for nuclear power plants including the two — La Salle 1 and Sequoyah 2 — which entered commercial service. With another seven licenses expected this year and 32 due in the next three years, the cumbersome licensing procedure is starting to move again. Installed nuclear capacity is now 65.7 GWe and the 296 billion kWh of electricity produced from nuclear energy exceeded electricity production from oil fired plants. Nuclear generation is also increasing its competitive advantage over base-load coal fired capacity and plant performance, which has been below the world average in the years since the Three Mile Island accident is climbing back slowly. Add to this the recent drop in interest rates and the first signs of economic recovery, and U.S. utilities may once more be ready to consider nuclear power in the second half of the 1980s.

Despite plant cancellations, the industry still has a substantial workload for the rest of the decade. There are some 59 plants in various stages of construction and of these only nine are below 25% completion. Another five units have been ordered but have yet to get a construction permit. Added to this program is a rapidly growing area of business for the nuclear service industry in support of the 147 operating plants. The utilities are well aware that the improvements in performance of these plants can do more to overcome their difficult financial problems than cancellations of new projects.

At the end of a turbulant year in nuclear politics, there was an important landmark with the passing of an act to give the U.S. a formal policy for dealing with nuclear waste. In a less happy state is the Clinch River breeder project and the Barnwell reprocessing plant. These are just surviving on stop gap funding arrangements and one of the main political challenges for the coming year will be to find an acceptable formula for government and industry participation in their completion.

On the legal front, the Supreme Court will this year be considering the equally sensitive political issue of whether the Federal Government can preempt state laws which seek to ban nuclear power plants. This is particularly important in California where the virtual moratorium on new nuclear plant construction in recent years has resulted in that state producing less than 3% of its large electricity demand from nuclear energy. With more than 60% coming from oil and gas it is not surprising that Californians have the highest electricity bills in the U.S.

South-east Asia showing the way

Massive inroads in south-east Asia have been made into the traditional world markets of the western industrial nations. At least three countries in that area are making strenuous efforts to substitute oil with nuclear energy in an effort to provide their industries with competitive electricity.

The Japanese nuclear industry has been through some difficult years. It suffered from a wave of public opposition, largely inherited from the U.S., also from rather poor performance of nuclear plants in the early years of operation. But the past year has seen a significant turn-around. Total generation from 25 operating nuclear power plants was over 100 billion kWh compared with 84 billion kWh in the previous year and for the first time nuclear generation is exceeding the country's only other source of low cost power — hydroelectricity. Authorizations for construction of new plants are starting to come through the revamped regulatory process and, together with projects in hand, Japan has a nuclear plant construction program for the rest of the decade which is hard on the heels of France. By 1990 nuclear generation should have more than doubled from

(continued on page 33)

The CANDU year in review

The past year will be remembered as a landmark — the year of the CANDU 600s.

While the established power reactors at the Pickering and Bruce nuclear generating stations continued to lead the world in performance, excitement stemmed mainly from the start-up towards the end of 1982 of three of the new standardized CANDU 600MW stations. A fourth, at Cordoba in Argentina, started up at the beginning of 1983.

Meanwhile, Romania, temporarily caught in a financial squeeze, was still pressing forward with civil engineering work on the first two units of a four-unit CANDU 600 station at Cernavoda, adjacent to the Danube Canal. This will minimize delays when Canada's International Development Corporation is in a position to resume disbursements from a $1 billion loan fund that has already been approved by the Federal Government in Ottawa.

The first three CANDU 600s, in the order they achieved criticality, were Point Lepreau, New Brunswick; Gentilly, Quebec, and Wolsung in South Korea.

A fifth reactor also started up, the first of the four Pickering B 516MW units, which have the same origins as the CANDU 600 general design, but with various detailed differences to line up with Ontario Hydro's internal standardization. This signalled a series of commissioning events in Ontario that will double that province's existing installed nuclear capacity.

Early in 1982, a Slowpoke 2 was sold to the University of the West Indies in Jamaica. The low power, unmanned reactor will be used for medical, environmental and other research.

In April, fuel loading was completed at both Point Lepreau and Gentilly 2. The month also witnessed the first of a number of operations during the year that demonstrated remotely-controlled repair capability. At Douglas Point, for example, a leakage of heavy water from several instrument systems was located in an inaccessible area above the calandria that was subject to high levels of gamma radiation. A pipe was frozen at a point above the leak, to create a temporary plug, and remotely-controlled tooling was used to replace the faulty components. In May, a leaking tube in the liquid zone control system of Bruce A, unit 1, was located and rectified.

The detection of a leak is always bad news but, in the case of Bruce A, unit 2, several were discovered during the year that brought good news as well. The discoveries confirmed that small cracks (about 15mm long) can sometimes occur in a reactor pressure tube, a critical pressure boundary, without initiating catastrophic ruptures in the system.

Help from remote controlled tooling

Remotely-controlled tooling devised for the purpose allowed rapid replacement of the leaking tubes, and the unit achieved a capacity factor of 68.2 per cent for 1982.

Remotely-controlled tooling techniques also promise to add an estimated three years to the life of pressure tubes in unit 1 of Pickering A. The problem stems from "creep", the progressive lengthening (about 5mm each year) of pressure tubes caused by the combined effects of high temperature, pressure and radiation.

The temporary remedy, that should postpone for three years the need to replace overlength tubes, lies in a procedure known as REFAB (for relocation of end fittings and bearings) that has been developed by AECL's Sheridan Park Engineering Laboratory. It has been tested on a mock-up of the Pickering A reactor face which has indicated that the procedure works very well.

In July, Point Lepreau achieved criticality and thus became the first of the standard CANDU 600s to start up. In August, the calandria for the last of the Bruce B reactors, arrived on site. All four units of Bruce A were given permission to increase the equivalent output power from 791MWe to 826MWe by the commissioning of additional process steam-producing capacity for the heavy water complex.

In September, a landmark of another sort: unit 3 of Bruce A nuclear generating station beat an earlier world record established by Pickering A, by operating continuously for 494 days without a reactor trip or shutdown. A machine, specially designed for commissioning purposes, was used for the first time to load fuel into unit 5, the first of the Pickering B reactors. Manual loading of fuel at Wolsung was also completed.

On September 11, Gentilly 2 achieved criticality; Pickering B, unit 5, followed suit in October. In November, Wolsung also went critical. It was also announced that a fall in the demand for

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Remotely-controlled tooling systems are emerging as a significant aspect of reactor service. Here, a prototype end fitting alignment system is applied to mock-up of a Pickering A reactor face.

electricity in Ontario had resulted in the addition of two years to the construction schedule of units 3 and 4 of Darlington, now scheduled for completion in 1992.

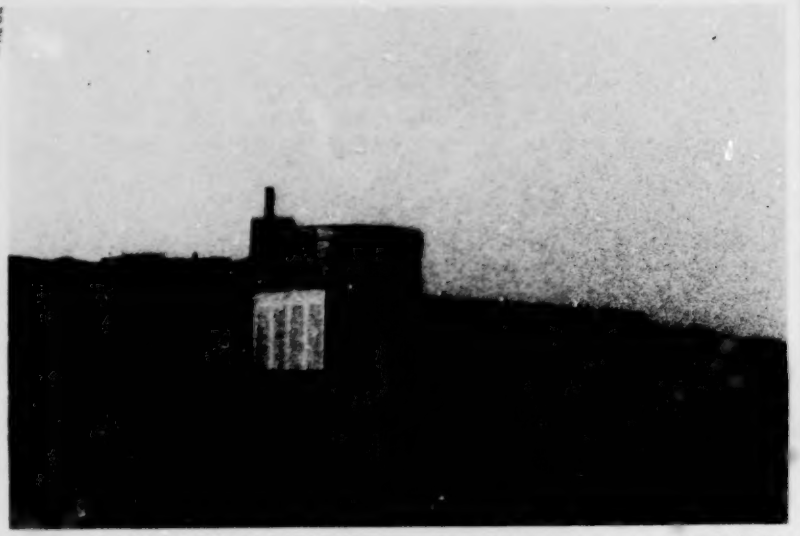
The CANDU overall operating record for 1982 proved again to be very satisfactory. Bruce 3 led the world with a hitherto unsurpassed capacity factor of 96.9%, while the average capacity factor for all Canadian nuclear units, including the prototype units at Douglas Point and NPD, was 82.6%. This was placed in perspective by Carl Goldstein, vice president of the United States Atomic Industrial Forum, who observed earlier last year that "the critics (of nuclear energy) contend that reactor manufacturers originally promised their customers 80% capacity factors, yet the best utilities can do is to eke out a mere 50 or 55%. An 80% capacity factor is considered pretty much an ideal, when you allow for annual refuelling and maintenance, which consumes about two months".

The achievement of first concrete pour to criticality in 62 months, achieved at Wolsung, was without precedent in North American experience, and another landmark for the CANDU 600 series. It made Wolsung a notable exception to worldwide experience that nuclear power stations commissioned after 1972 have taken significantly longer to design, construct and bring into service than plants committed before that date.

It was fortunate that the Wolsung steam generators did not suffer the defects in boiler tubes that were discovered during the construction period in the other 600MW projects. The projects had suffered 18-month delays due to these defects. Another major cause of delays in several projects was the late identification of new regulatory requirements and a re-interpretation of existing requirements, all of which resulted in disruption of design and construction programs.

At Gentilly 2, there had been the assumption that river water, non-tidal at that point in the St. Lawrence, could be used for condenser cooling. This proved to be optimistic, due to the presence in the water of potentially corrosive industrial wastes. As a result it was necessary to incorporate secondary heat exchangers to isolate the river water from the condensers.

Factors similar to those arising in the licensing of plant made it difficult for the New Brunswick Power Commission and Hydro Quebec to anticipate in a timely manner the departures from traditional training programs that would be required to prepare operators to pass evolving licensing exams. The resulting delay in obtaining enough licensed operators put this part of the program on the critical path.



The Wolsung 600 MW CANDU plant in Korea went from first concrete pour to criticality in 63 months.

Contrary to popular belief, changes in licensing requirements were being called before, not only as a result of, the accident at the Three Mile Island in Pennsylvania. Needed or not, they came as a result of pressure exerted on nuclear regulatory bodies by opponents of nuclear power.

Another contributory factor was the long delivery times for many parts, ranging from instruments to major components such as pumps that were experienced by North American industry as a whole.

There were, therefore, large disparities in the time taken to bring the various stations from first pouring of concrete to nuclear criticality, as indicated by the table below:

Station	First pour of concrete	Criticality	Full-power
Gentilly 2	May 1974	11 Sept 1982	31 March 1983
Cordoba	March 1975	13 March 1983	
Pt. Lepreau	June 1975	22 July 1982	27 March 1983
Wolsung 1	Oct 1977	21 Nov 1982	25 March 1983*

The flow of information from Point Lepreau and Gentilly 2, the reference station, contributed greatly to shortening the commissioning process at Wolsung. There always had to be a first and, with the 600s, it was Point Lepreau. Exchanges of information also led to certain evolutionary changes in the construction process, particularly at Wolsung. Several licensing changes introduced during the Gentilly 2 and Point Lepreau projects caused disruptions in planning and construction. As one program engineer remarked later, "if you have not already built the darned thing, it is a heck of a lot easier to introduce changes".

The standard 600s follow closely in basic design the Pickering A CANDU design and changes that were introduced were more in the nature of extensions to, rather than departures from the Pickering approach.

Design characteristics of the 600s

The CANDU 600 calandria, or reactor shell, is a thin-walled (28.6 mm) stainless steel horizontal stepped cylinder 7.6 m diameter, closed at each end and pierced by 380 horizontal calandria tubes, each 6 m long, which are surrounded by cool, low pressure, heavy water comprising the moderator.

Fuel bundles, 12 to each channel, each bundle containing 37 separate tubular elements containing the uranium oxide pellets, are supported in pressure tubes that pass concentrically through the gas-filled calandria tubes and are linked at each end by piping to headers, and then to the steam generators.

Nuclear heat is removed by heavy water of the separate primary coolant circuit, and circulates through the

steam generator tubes before being returned by pumps to the reactor. The primary coolant water enters the reactors at 267°C and 11.23 MPa(abs) and leaves at 310°C and 10 MPa(abs) to produce a total steam output from the boilers of 1033 kg/s with a pressure at the turbine of 4.55 MPa(abs).

By redesigning the Pickering-type fuel elements, it has been possible to provide for the extraction of more energy (600MWe) from the 380 fuel channels of the standard CANDU 600 than from the 390 fuel channels of the Pickering A units which have an output of 514MWe.

Whereas Pickering A, designed to meet the needs of the Ontario Hydro grid system is a cluster of four units that depend for containment of any accidental overpressures on use of a common evacuated chamber, or "vacuum building," the standard CANDU 600 containment is self-sufficient. The domed building of reinforced concrete, 43.6 m diameter and 51.2 m from basement to top, has a wall thickness of 1 m and a design pressure of 124 kPa (gauge). Its volume is 48,478 m^3. Coupled with the internal water dowsing system, it is capable of absorbing any overpressure that might result from a leak or from a major rupture of the primary coolant circuit.

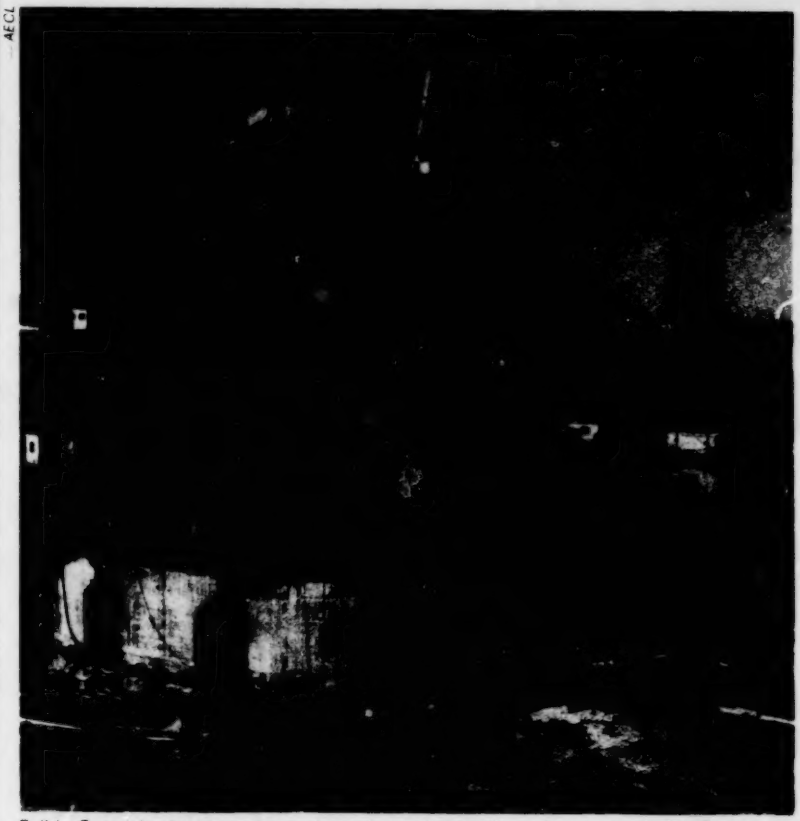
The CANDU 600 also enjoys benefits of scale and simplification, by using fewer and larger components. For example, Pickering employs 12 steam generators per reactor. The CANDU 600 has only four, of larger size. Pickering units use 16 main circulating pumps, of which four are spares. The 600s have only four pumps of similar but more powerful design, and this modification has been found to be completely satisfactory.

CANDU-type steam generators have always performed very well. The fact that the reliability record for tubes in these stations is two orders of magnitude better (0.02 per cent failures compared with 2.0 per cent) than the general experience world-wide, is largely ascribed to conservative design, careful selection of materials, meticulous control of workmanship and production procedures, elimination of potential areas of stagnation or overheating and good process chemistry during operation.

In all cases except Cordoba, where the design was finalized earlier, all three parallel trip circuits of both shutdown systems are controlled by separate fail-safe microprocessors.

Commissioning experience

Commissioning experience with the CANDU 600s has been very good.



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Fall in Ontario's electricity demand resulted in the addition of two years to the Darlington construction schedule of units 3 & 4. Photo shows vacuum building construction last September.

Although accurate comparisons are difficult, AECL staff say their impression is that there have been progressively fewer problems than in the commissioning of previous CANDU types at an equivalent stage of development. This, despite the added complexity resulting from recent new regulatory requirements and the distance from base which, in the case of Wolsung, amounted to 18,000km, with no telephone line until the project was almost finished. Engineers speak jokingly of Wolsung as the first nuclear power station to be built by telex!

"Remotely-controlled tooling techniques also promise to add an estimated three years to the life of pressure tubes in Unit 1 of Pickering A."

The process of commissioning of the various stations was sequential and evolutionary. This was nowhere more dramatically demonstrated than when the various commissioning teams came to load fuel. At Point Lepreau, the process took about 12 days; at Wolsung everyone felt they did a very good job when they cut the time down to eight days; yet when it became Cordoba's turn they completed the whole process in two days, eight hours and ten minutes!

At Point Lepreau, where the New Brunswick Power Commission had devoted a major effort to training its own staff right from the start, there were nevertheless about 20 AECL staff also in attendance. At Gentilly 2, commissioning was primarily the task of Hydro-Quebec. Particularly in the case of Wolsung, engineers and technicians seconded from Ontario Hydro were immensely helpful, constituting about 80% of the Canadian expatriate team of 40. At Cordoba, where the expatriate team was also a composite one, and at Wolsung, staff of the respective nations provided staff of their own to duplicate for each of the Canadians. This fact, combined with the extensive transfer of Canadian technology that characterized both programs, and the intensely enthusiastic attitude of the Koreans and the Argentinians, promises well for the future of these plants. ■

The 1983 Uranium Picture

By T. David Smith,
Director of Information,
Eldorado Resources Ltd.

Canada's uranium industry is on the verge of setting new production records.

Preliminary statistics assembled by the federal Department of Energy, Mines and Resources show that Canada's seven producers had total production during 1982 of 8,050 tonnes of uranium in the form of uranium oxide (U_3O_8), the industry's largest output in 20 years.

Total shipments last year amounted to 8,200 tonnes U. EMR estimates that these shipments generated about $815 million in revenues, mostly foreign exchange from the industry's export customers.

The all-time production record was, of course, set in the late 1950s when the industry was producing yellowcake exclusively for the United Kingdom and United States defence programs. In 1959, some 12,200 tonnes U was produced and shipped to the only two customers the industry had in those days before the development of a commercial nuclear reactor industry. These 1959 exports brought a total of $331 million into the country, more than any other metal and third among all exports. (This is equivalent to about $1,260 million in 1982 dollars.)

Today, the market is much different. Since 1965, federal government policy has prohibited the export of Canadian-produced or -processed uranium to any country for the purpose of making nuclear weapons. In the intervening 20 years, a sophisticated market has evolved, with more than 100 utilities whose sole purpose is generating electricity.

Industry Consolidation

During the industry's early years, as many as 20 companies were in production. In 1982, there were only seven — four in Ontario (Denison Mines Limited and Rio Algom Limited at Elliot Lake, Agnew Lake Mines Limited near Elliot Lake and Madawaska Mines Limited near Bancroft) and three in Saskatchewan (Amok Ltd. at Cluff Lake, Eldorado Resources Limited at Uranium City and the Rabbit Lake mine and mill purchased by Eldorado in October 1982 from Gulf Minerals Canada Limited).

This consolidation trend continued last year with the closing of relatively small, high-cost mines by Madawaska and Eldorado (Uranium City). Mining at Agnew Lake ceased in 1980 and recovery of uranium from mine water and surface heap leaching operations was scheduled to stop in early 1983.

"...simply a matter of time before the Uranium industry will once again contribute more than $1 billion to the Canadian economy..."

One of the world's largest mines

While those mines were no longer able to compete in world markets, a single new mine being brought into production this year will more than make up for the three closures. With an annual production capacity of 4,600 tonnes U and contracts with both domestic and foreign utilities, the Key Lake mine and mill in northern Saskatchewan is expected to start up at close to capacity, making it Canada's largest single producer and one of the largest uranium mines in the world.

This development, coupled with the investment of some $800 million by Denison, Rio Algom and Ontario Hydro in the expansion of Elliot Lake capacity and production, will ensure that the industry will set all-time production records in the mid-1980s. It is simply a matter of time before the uranium mining industry will once again contribute more than $1 billion annually to the Canadian economy as a result of ongoing production (i.e. excluding capital expenditures and exploration).

Ontario continues to be the major uranium-producing province, accounting for 64 percent of 1982 output with the balance coming from Saskatchewan. However, the Key Lake mine should push the western province over the 50 percent mark within the next few years.

The recent and continuing growth in uranium production may come as a surprise to some within the nuclear industry, which tends to focus on the number of new reactor orders placed each year. But the driving force behind the increasing demand for uranium is

TABLE I: Uranium Exploration Activity

Year	Expenditures[1] (Mlns. Current $)	Drilling[2] (Kilometres)	Number of Projects Over $1 Mln.	Number of Projects
1976	$ 43.5	137.3	4	187
1977	$ 71.7	304.1	4	500
1978	$ 90.0	333.9	7	508
1979	$129.5	483.3	24	513
1980	$128.0	503.3	24	377
1981	$102.1	358.8	24	324

1. *Direct exploration and drilling costs*
2. *Exploration and surface development drilling; excludes development drilling on producing properties*

TABLE II: Canada's Mineable Uranium Resources

(Thousands of tonnes Uranium in mineable ore)[1]

Mineable at Prices[2,3]	Measured 1981	Measured 1980	Indicated 1981	Indicated 1980	Inferred[4] 1981	Inferred[4] 1980
Up to $110/kg U	45	67	153	163	142	214
$110 to $160/kg U	2	6	12	22	39	101
Sub-total	47	73	165	185	181	315
$160 to $320/kg U	24	NR	41	NR	44	NR
Total	71	—	206	—	225	—

1 Milling losses have **not** been deducted.

2 The dollar figures refer to the market price of a quantity of uranium concentrate containing 1 kg of elemental uranium. The prices were used in determining the cut-off grade at each deposit assessed taking into account the mining method used and milling losses expected.

3 The 1980 assessment used price ranges of up to $135/kg U and $135 to $200/kg U. Thus, in 1981 the measured resources of 45,000 tonnes U at prices up to $110 are compared with 67,000 tonnes U at prices up to $135 in 1980.

4 Principal properties only.

NR Not reported in 1980.

not the reactor orders placed in the last five years but those placed during the mid-1970s. These reactors are nearing completion of construction and utilities are contracting for uranium to meet their requirements in the late 1980s and 1990s.

Installed nuclear-generated electricity capacity in the western world will increase 135 percent between 1981 and 1990 to 310 gigawatts. Furthermore, unlike most other suppliers to nuclear reactors, the uranium industry must re-supply the reactors as fuel is burned up.

Exploration has declined

In contrast with uranium production, the Canadian industry's total expenditures on exploration declined 20 percent, according to EMR's Uranium Resource Appraisal Group (URAG), from $128 million in 1980 to $102.1 million in 1981. This was the first decline in more than five years. Exploration and surface development drilling dropped 30 percent to some 359,000 metres, down from the record 503,000 metres in 1980 (Table I).

Both declines reflected the sharp drop in uranium spot prices, which began in 1979 and didn't bottom out until late 1982. Another inhibiting factor was the adequate world-wide supplies of developed uranium reserves and production capacity for the near term.

The decline in spot prices and rising costs of production had a pronounced effect on Canada's estimated uranium reserves, according to URAG. Table II shows that at the end of 1981, the amount of Canadian uranium which could be mined at prices up to $160/kg U declined 36 percent in the Measured, 11 percent in the Indicated and 43 percent in the Inferred categories. (The weighted average price of Canadian uranium delivered to foreign utilities in 1982 was $113/kg U.)

The result of the price and cost trends was "a reduction in the level of resources that are of economic interest in the immediate and near term," according to URAG. However, Canada's long-term uranium resource base is much larger, assuming prices up to $320/kg U.

Investment in Uranium Processing

Uranium mined and milled in Canada is refined and converted into nuclear fuel material by Eldorado Resources Limited, the federal Crown corporation. As outlined in April 1980 by then-Energy Minister Marc Lalonde, "Federal government policy requires that uranium mined in Canada and surplus to domestic requirements be processed to the most advanced form possible prior to export, provided (a) processing capacity is available in Canada and (b) that capacity is economically competitive."

In order to ensure an adequate and cost-competitive Canadian capacity for refining and converting uranium, Eldorado is nearing completion of a major expansion program at a new site near Blind River in the Elliot Lake area of Ontario and at its existing operations in Port Hope, Ontario.

The Crown corporation is building a $130 million refinery at Blind River with capacity to refine 26,000 tonnes of uranium concentrates or yellowcake into nuclear-grade uranium trioxide (UO_3) containing 18,000 tonnes of uranium. Once in operation during the second half of this year, UO_3 will be shipped to Port Hope for conversion into uranium dioxide (UO_2) for CANDU reactors and into uranium hexafluoride (UF_6) for foreign light water reactors.

At Port Hope, the old UO_3 refinery will be shut down and Eldorado is building a $100 million UF_6 conversion plant, which will increase its UF_6 capacity from the current 5,000 to 14,500 tonnes U.

During 1982, the company set processing records, producing UO_2 containing 1,577 tonnes U and UF_6 containing 4,762 tonnes U. ■

TABLE III: Uranium Exploration Expenditures and Drilling by Province or Territory, 1981

	Expenditures $ Million	Drilling[1] Metres x1000
Saskatchewan	60.8	300.7
Northwest Territories	23.6	22.6
Quebec	8.8	18.5
Nova Scotia	3.0	9.3
Newfoundland	1.6	2.7
Alberta	1.1	0.6
Ontario	0.9	3.0
New Brunswick	0.8	1.0
Yukon Territory	0.7	0
Manitoba	0.2	0.4
British Columbia	0.1	0
Unspecified	0.5	0
Total	102.1	358.8

1. Includes exploration drilling and surface development drilling.

WORLD REVIEW

(continued from page 28)

the present level which accounts for about 20% of the country's electricity.

The other two south-east Asian countries forging ahead with nuclear power are South Korea and Taiwan. The end of the year saw the start up of South Korea's third plant — the CANDU reactor at Wolsung — and the rest of the decade should see the addition of one further 900 MWe PWR each year together with the ordering of a further two units per year for operation in the 1990s. This program, which is still considered by some to be over-optimistic, represents a downward revision of earlier plans due to lower growth forecast in the wake of worldwide recession.

Taiwan also revised downwards the projection of growth in electricity demand as a result of a slow down in world trade and, at the last minute, postponed for two years the placing of orders for the country's fourth twin-reactor nuclear power station. But this small island's fourth reactor was coupled to the grid at the end of 1982 and two further units are due to start up in 1983 and 1984. This will increase the installed capacity from the present level of just under 3000 MWe to nearly 4000 MWe and the contribution of nuclear electricity will go up from 25 to 35 percent. ■

The Status of Nuclear Waste Management in Canada

By E. R. Frech

Despite the success of Canada's nuclear power program, there is a nagging doubt in the minds of the Canadian public. What about nuclear waste? Isn't it true that there's no proven way to get rid of it? Doesn't it last practically forever? Don't the critics say that if we don't stop producing it, it will get us all in the end?

In view of these questions from the public, it behooves the members of the nuclear industry to ask one of their own: Just how big is this problem that's been described as the Achilles' heel of our industry, and what's being done about it?

Wastes are produced at all stages of the nuclear fuel cycle, starting with the extraction of uranium ore from the ground and proceeding through its processing into fuel, the operation of the reactors and the creation of new radioactive elements in the fuel within the reactors. In addition, there are radioactive wastes associated with various activities made possible by the nuclear industry, such as the use of medical isotopes for the diagnosis and treatment of disease, and the use of radioactive sources in a variety of industrial applications.

All nuclear wastes can be roughly classified into three major categories: mine tailings, low- and medium-level wastes and nuclear fuel wastes. The characteristics of these wastes and the techniques for managing them are discussed below.

Mine Tailings

Most uranium ores mined today contain from 0.05% to 0.20% uranium, with some recently discovered high-grade deposits containing as much as 8% uranium. Thus, for most operations, the recovery of one kilogram of uranium produces from 0.5 to 2 tonnes of waste, which is contaminated with naturally occurring radioactive materials. Of the total radioactivity in the ore, about 15% is associated with the extracted uranium, and about 85% is left behind in the waste.

When uranium ore is processed, it is first ground to a fine sand to allow the uranium to be leached out via chemical processes. The residual sand is discharged from the uranium mill as a slurry, into a tailings pond where the solids settle out. The liquid is decanted into a precipitation basin, where barium chloride is added to precipitate out dissolved radium-226, and the water is released to the natural watercourse.

While the radioactive materials associated with mine tailings are naturally occurring elements, the fact that the rock has been taken to the surface and ground into a fine sand makes these materials much more available to man's environment.

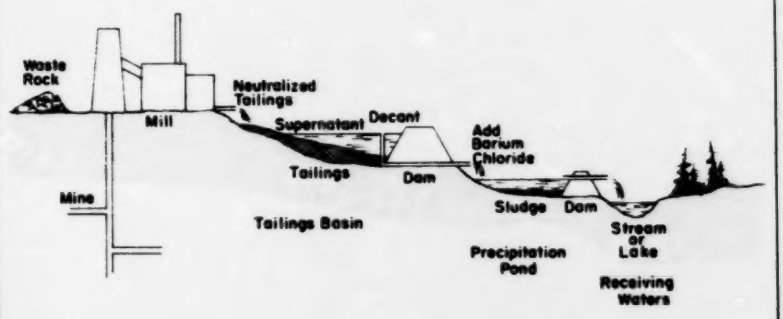
"$34 million per year used fuel program will culminate in technical review and public hearings near the end of this decade"

Another problem is the presence of sulphides in some ores which can oxidize, and when dissolved in water the oxides lead to the production of acid. Acid discharges from the Elliot Lake, Ontario tailings piles in the 1950s and 1960s caused severe environmental damage to the Serpent River system.

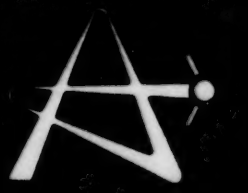
Modern tailings management practices control acid discharges by the addition of lime, and control the airborne release of radioactive materials by keeping the tailings wet, covering them with soil and vegetation, using them as mine backfill (Beaverlodge, Saskatchewan) or keeping them in concrete bunkers (Cluff Lake, Saskatchewan). These measures are sufficient to meet federal regulatory requirements for storage of these wastes.

About 120 million tonnes of uranium tailings exist in Canada today, in seven general areas of Ontario, Saskatchewan and the Northwest Territories. If uranium continues to be produced at the rate projected, these tailings would total 300 million tonnes by the year 2000. While these amounts might seem large, currently the uranium tailings represent only about 2% of all mine wastes in Canada.

The federal government is at present assessing the various alternatives for the permanent disposal of the tailings following the closing of a uranium mine. A $9.5 million, five-year research pro-



Typical sequence of steps for dealing with uranium mine tailings. About 120 million tonnes of uranium tailings exist in Ontario, Saskatchewan and Northwest Territories.



Discover a New Resource

ChalkRiver

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Chalk River, Ontario K0J 1J0
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Ontario Hydro's facility for management of low and medium-level wastes at the Bruce site in Southern Ontario.

gram under the direction of the Canada Centre for Mineral and Energy Technology, a division of Energy, Mines and Resources Canada, is considering such alternatives as surface disposal, shallow burial, deep burial and deep lake disposal.

Mining companies, which have the primary responsibility for disposing of their tailings, are required to submit proposals for the close-out of their operations to the Atomic Energy Control Board for review. The federal government has accepted ultimate responsibility for tailings disposal, in case a mining company is unable to pay.

The Atomic Energy Control Board has started the process of developing criteria for the permanent disposal of uranium mine tailings, and this question can be expected to be resolved within the next few years.

Low and Medium-Level Wastes

Low and medium-level radioactive wastes include wastes arising from the nuclear fuel cycle other than mine tailings and used fuel. They thus include wastes arising from the operation of nuclear power plants, from industries, universities and hospitals, from the production of radioactive isotopes and from nuclear research activities. About 15,000 cubic metres of such wastes are produced in Canada yearly.

Active storage facilities for these wastes are located at the Chalk River Nuclear Laboratories (CRNL) and Whiteshell Nuclear Research Establishment (WNRE) of Atomic Energy of Canada Limited (AECL), at Port Granby, Ontario, at the Bruce Nuclear Power Development in Ontario, at the Gentilly nuclear power station in Quebec, at the Point Lepreau nuclear power station in New Brunswick, at the University of Toronto and at the University of Alberta. Additional storage facilities are located in Hope Township in Ontario and at Suffield, Alberta, but these are currently not being used.

"None of the present low-level waste management methods can be considered permanent disposal"

Residues and garbage arising in the refining of uranium constitute the largest volume of these wastes. About 5,000 cubic metres are produced annually, and about 215,000 cubic metres have been accumulated to date. The uranium refining industry is dealing with the waste problem in two ways, (i) by converting to processes that do not produce as much waste, and (ii) by recycling some of the waste products. Ammonium nitrate, for example, is sold as fertilizer. Raffinate from the refining process is sent to uranium mills for the extraction of the residual uranium. Calcium fluoride sludge is still buried at the Port Granby waste management site, but efforts are being made to recycle it through the steel industry, as a flux. Scrap metal from old plants is also gradually being recycled. Ordinary garbage is incinerated to reduce its volume, and the residues are buried at the Port Granby waste management area.

Fuel fabricators, who together produce about 1,000 cubic metres of low-level radioactive wastes per year, transport this material to the CRNL waste management site, as do the users of radioisotopes, who are responsible for about 500 cubic metres of waste per year.

Electrical utilities produce about 4,000 cubic metres of low and medium-level waste per year, ranging from material mildly contaminated with fission products or tritium, to ion-exchange filters that are sufficiently contaminated to require shielding.

Waste management processes at AECL's research laboratories and at the power plants consist of volume reduction by incineration or compaction, and storage in concrete structures at or near the surface. About 60,000 cubic metres of such wastes are now in storage.

In addition to the above, there are about 2,000,000 cubic metres of contaminated soil at CRNL and about 700,000 cubic metres of "historic" waste elsewhere in the country, consisting largely of soil slightly contaminated with radium-226, thorium, uranium and arsenic. These wastes are located in Scarborough, Port Hope, and Bancroft, in Ontario and in other areas associated with past activities, such as the extraction and refining of radium. In the case of Port Hope, which presents the largest problem, contaminated material has been widely distributed through the community. Remedial measures have been undertaken, and about 450 buildings and sites have been decontaminated. About 200,000 tonnes of contaminated material still remain in seven open areas and ravines in and around Port Hope, and the town's yacht basin is contaminated with radium.

None of the present low-level waste management methods can be considered permanent disposal, and the

industry is starting to deal with this question. AECL and Ontario Hydro have begun the process of identifying the steps leading from the current storage methods to licensed permanent disposal sites, and the federal government has recently announced the formation of a Low Level Radioactive Waste Management Office within AECL to deal with the outstanding problems of historic wastes and with the disposal of low-level wastes generated by operators who do not have their own waste management facilities.

Nuclear Fuel Wastes

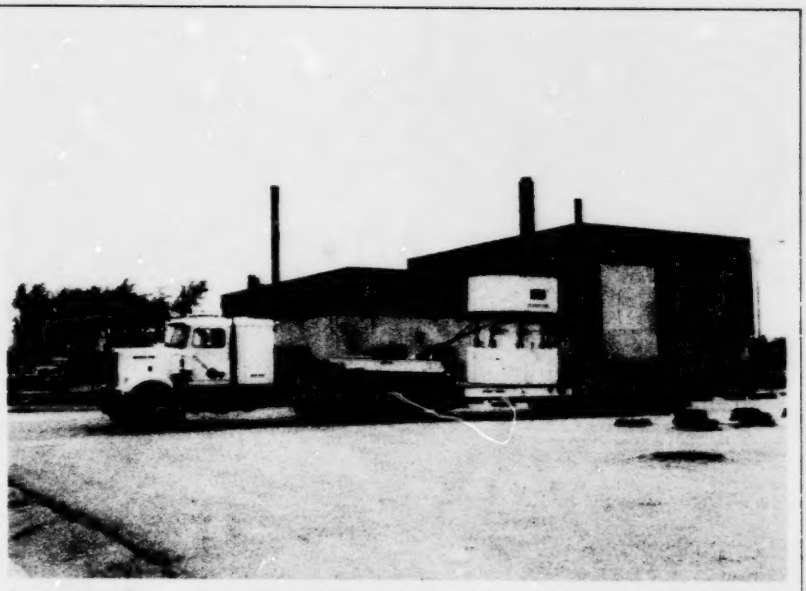
When uranium is used as a fuel in a nuclear reactor, small quantities of radioactive materials are created. They represent only one percent of the used fuel, but they interfere with the chain reaction and make it necessary to remove the fuel after about 18 months in the reactor. The new radioactive materials consist of fission products, most of which decay in the first 500 years, and actinides, which represent a long-term medium- and low-level waste management problem.

"The radiation dose... from an underground disposal facility in the first million years of operation would not exceed one percent of natural background radiation."

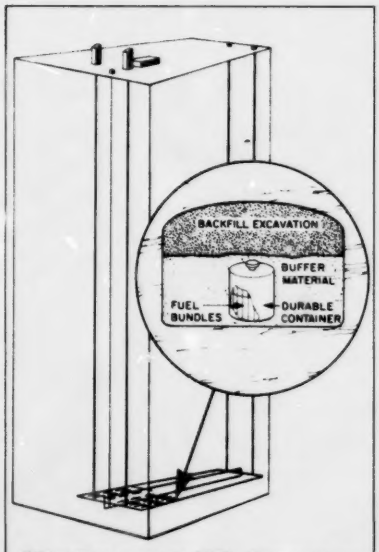
Virtually all of the used fuel is at present stored in 9 metre deep water-filled pools, which provide cooling, shielding and isolation from the environment. At WNRE, a small quantity of used fuel from the WR-1 research reactor is stored in above-ground concrete canisters.

Ontario Hydro, by far the largest generator of used fuel in Canada, had about 270,000 used fuel bundles (approximately 6,400 tonnes) in storage at the end of 1982. Smaller quantities exist at WNRE, CRNL, and Gentilly, Quebec.

Used fuel does not present any immediate health or environmental hazard, and it is estimated that current storage practices could be continued for at least 50 years, with new facilities being built as required. However, the federal and provincial governments have recognized the desirability of providing a final solution for the management of nuclear fuel wastes, and in 1978 established an extensive research and development (R&D) program to develop technologies for the storage, transportation, immobilization and final disposal of nuclear fuel wastes. The disposal concept is based on deep burial of the immobilized wastes in a stable hard-rock formation in the Canadian Shield. The R&D program is currently funded at about $34 million per year by AECL and Ontario Hydro, and will culminate in a technical review and public hearings on the disposal concept near the end of this decade.



Flask built to Ontario Hydro specifications for transporting radioactive ion exchange resins from reactor to the Bruce waste site. Volume reduction takes place in incinerator building in rear.



$34 million per year AECL-Ontario Hydro used fuel disposal program is based on deep burial of unmobilized wastes in stable hard rock formations of the Canadian Shield.

The disposal technology being developed by AECL involves a multiple-barrier system designed to ensure that the wastes will not reach the environment during their hazardous lifetimes in sufficient quantity to harm man. The barriers include a highly insoluble waste form, corrosion-resistant containers, nuclide-absorbing buffer material and the very long pathway that waste dissolved in slow-moving groundwater would have to travel to reach the surface.

AECL's preliminary assessment of the disposal concept indicates that for the vast majority of scenarios studied the radiation dose to the most exposed member of the public from an underground disposal facility in the first million years of operation would not exceed one percent of natural background radiation.

Conclusion

Radioactive wastes in Canada today are well managed, and current practices are adequate to satisfy the health protection guidelines set by the regulatory agencies. The nuclear industry and the agencies of the federal and provincial governments concerned are addressing the question of final disposal of wastes arising from all parts of the nuclear fuel cycle, as well as those from various other current and historic uses of radioactive materials. Some decisions on the extent to which disposal is required, particularly for low-level, historic and mine wastes, remain to be made, but the process of making those decisions has been started. ■

Radioisotopes — an important part of Canada's nuclear industry

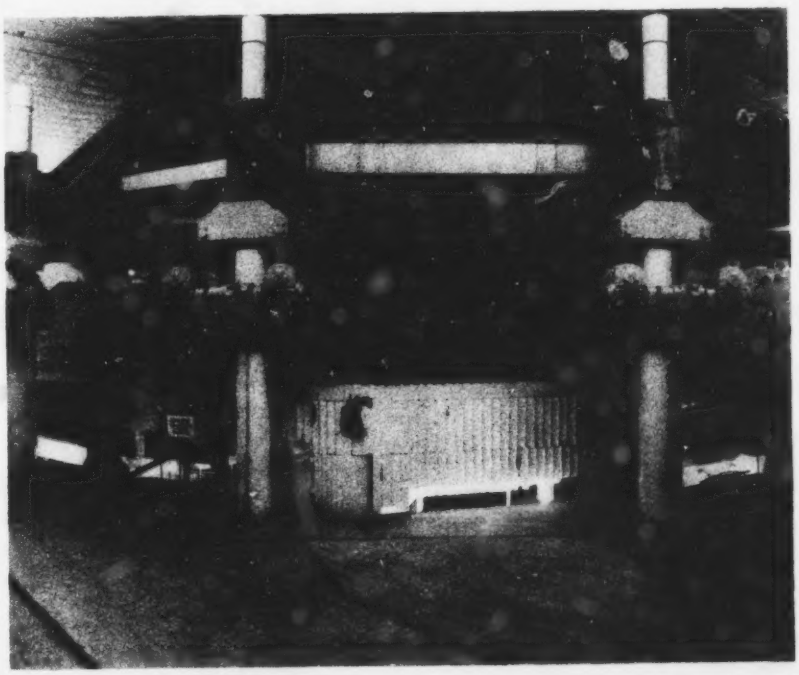
Canada's radioisotope industry is much smaller in physical and financial scope than the reactor electric power program. Nevertheless it is making a contribution worldwide that is proportionately far greater than the country's involvement in other high technology fields.

By D.J.R. Evans, Atomic Energy of Canada Ltd. Radiochemical Company

Radioisotopes are radioactive variants of naturally occurring elements. Although a few radioisotopes occur in nature, usually with very long half-lives, most isotopes in common use today are artificially made radioactive. Isotopes with an excess of neutrons are best produced by processing targets in a high flux reactor. On the other side of the nuclear stability line are the nuclides which are neutron deficient and which are produced in an accelerator or cyclotron.

The higher the available flux in a reactor the easier and more efficiently can a useful radioisotope be produced. In Canada, AECL's NRX and NRU reactors at Chalk River (with neutron fluxes greater than 10^{14} n/cm^2.s), provide the raw materials needed for around 65% of all the bulk processed radioisotopes in use world-wide today. At the same time, Ontario Hydro's CANDU reactors are used to produce very large quantities of cobalt-60 for use in industrial sterilization plants and material irradiators.

Neutron deficient radioisotopes are produced in two cyclotrons at TRIUMF[1] in Vancouver. AECL's Radiochemical Company (RCC) signed an agreement with TRIUMF in 1978 to irradiate, process and market medical isotopes using the main TRIUMF cyclotron, and an additional small dedicated cyclotron on the same site. Following irradiation, target materials are chemically processed to reach desired levels of purity, then encapsulated, or further refined for medical use.



Radioisotopes for medical applications are produced in two cyclotrons at the TRIUMF facility in Vancouver.

Uses of isotopes

A statement in 1954 by Gordon Dean, then Chairman of the US Atomic Energy Commission, remains appropriate today. He wrote:

> "Isotopes are used to treat the sick, to learn more about disease, to improve manufacturing processes, increase the productivity of crops and livestock, and help man understand the basic processes of his body, the living things around him and the physical world in which he exists".

This quotation can be broken down into its constituent parts and used to illustrate the wide and varied applications of isotopes, either on their own, or in radiation equipment.

Treating the sick, learning about disease

When a citizen of North America enters a hospital with an ailment requiring diagnostic procedures there is a 30% chance that a radioisotope will be utilised in his diagnosis work-up.

In-Vivo Diagnosis

These procedures involve the administration of radioisotopes to a patient either as a simple inorganic chemical or in complex biologically active compounds. Subsequent measurement of activity distribution is used to delineate body organs, locate tumours or measure organ dysfunction.

While a variety of reactor-produced isotopes have been utilised to produce radiopharmaceuticals, the field today is dominated by technetium-99m which

1. *TRIUMF — Tri-Universities Meson Facility, jointly operated by the Universities of Alberta, British Columbia and Victoria, and Simon Fraser University.*

possesses the most desirable collection of properties for nuclear medicine of all currently known radioisotopes. It emits a single gamma photon energy ideal for organ imaging. It has high specific activity and thus little chance for toxicity problems. Its compounds can readily be used for visualising a variety of different body organs and its short, 6-hour, half-life minimises any unnecessary radiation dose to a patient.

With a 6-hour half-life, the isotope possesses some commercial logistical problems. Fortunately, technetium-99m is produced from a parent nuclide, molybdenum-99, which has a much longer half-life of 66 hours. This is long enough to remove a target from a reactor, process it to pure Mo-99, and ship this to a radiopharmaceutical manufacturer anywhere in the world. He, in turn, prepares a Tc-99m generator from the molybdenum-99 and ships it to a hospital while there is sufficient radioactivity left for the doctor to use.

RCC is the world's largest producer of fission molybdenum-99; in 1982 over a quarter of a million curies were processed and shipped to customers.

The molybdenum-99/technetium-99m generator, or "cow", consists of an inorganic ion exchange column from which the daughter technetium-99m is eluted as pertechnetate with physiological saline. At present over 5000 generators are shipped every week to hospitals around the world, with more than half of these filled with molybdenum-99 supplied by RCC.

Cyclotron-produced isotopes (thallium-201, iodine-123, gallium-67 and indium-111) are becoming increasingly important. Such isotopes, produced by bombarding the nucleus with particles accelerated in a cyclotron, are also carrier free and low in patient radiation exposure. Thallium-201 is now widely used in the fast, painless diagnosis of myocardial malfunctions. Iodine-123 will represent an even greater challenge to the logistical capabilities of commercial producers than does molybdenum-99 since it has a half-life of only 13 hours. Positron-emitting isotopes such as carbon-11 and gallium-68 permit organ function, rather than shape, to be studied. Small quantities of some of these isotopes, for evaluation purposes, are produced in a new facility attached to TRIUMF in Vancouver. Positron emission tomography is a new technique which uses the specific decay properties of positrons, in conjunction with sophisticated detection and computer systems to generate three-dimensional views of organ shape and function.

In-Vitro Diagnosis

These procedures, principally radioimmunoassays (RIA's), represent the fastest growing area of clinical isotope usage. Antigen-antibody complexes are formed by mixing radioisotopically labelled antibodies with unlabelled natural antigens in blood or other samples. The amount of radioactivity found at equilibrium is a measure of the naturally occurring antigen in the sample. These tests are rapid, simple to perform, and are widely available in kit form. They use inexpensive instrumentation and therefore are accessible to small decentralized clinical laboratories. Carbon-14, iodine-131 and iodine-125 have all been used for this purpose; however, because of its ease in handling and measurement, iodine-125 is now the isotope of choice. The quantity of activity used is so small that for some applications 1-10 million assays may be performed from one curie of iodine-125. RCC supplies over 50% of the world demand for each of these three isotopes.

"...NRX and NRU reactors at Chalk River provide the raw materials needed for around 65% of all the bulk processed radioisotopes in use world-wide today."

Improving manufacturing processes

Various manufacturing processes have been improved by radioactive isotopes and many commodities are dependent upon them.

Radiography utilises gamma irradiation from radioisotopic sources (principally iridium-192) to detect structural faults, impurities, porosities in metal components, such as aircraft castings, and welds in oil and gas pipelines. These sources are more penetrating than conventional x-rays, are portable, do not require high voltage power, and are thus very convenient for field use. More than 800 iridium-192 sources, over 75% supplied by RCC, are used in Canada each year, with each one performing 5 to 50 radiographs per day during a useful life of 3 to 6 months. These play an important part in environmental protection and personal safety.

Many sophisticated electronic gauges used in industrial and process control are based on nuclear radiation. Examples are level and density gauges measuring and controlling the thickness of sheet material such as plastic films, metal foils, sheet strips and also coatings of metal or plastic on a wide variety of materials. Isotopes commonly employed are caesium-137, krypton-85, or strontium-90.

Radioisotopes are also used as tracers to find lost buried pipes or leaks in pipes or storage tanks. Flow patterns and foam/solution conditions may be monitored in closed reaction vessels. The forecast growth of secondary oil production in the national energy program over the next two decades requires the development and optimisation of novel enhanced oil recovery techniques, such as water flood, liquid CO_2 flood and fire flood. Radioisotopes are used as tracers to delineate the underground pathways in the oil bearing strata between injection and production wells. By injecting different radioisotopes into a series of injection wells, and measuring the breakthrough time and pattern of each at the production well, it is possible to determine the most economical oil recovery technique. A wide variety of beta and gamma emitting radioisotopes are suitable — cobalt-60, cobalt-57, caesium-137, caesium-134, strontium-90, carbon-14 and tritium. In the recent study RCC injected three different isotopes into 30 oil wells, and this technology is expected to become more widely used as secondary oil production increases.

Smoke detectors using the ionization principle operate by sensing continuously the ionization current in a chamber containing a small, radioactive source. When combustion products enter the chamber the current drops and an alarm is activated. The extremely small amount of radioactivity used — typically one microcurie or less — ensures safety.

Increasing productivity of crops and livestock

The uptake of radioisotopes from soil or nutrient solutions by plants and animals has been used to study trace element deficiencies and the effects of fertilisers. Radioactivity labelled pesticides and environmental contaminants have been followed through their sequences of distribution, metabolism and ultimate degradation or deposition. Tritium has been used to find the origins of groundwater, flow velocity and direction. In Ontario, phosphorus-32 has been em-

(continued on page 44)

Half a Century of Nuclear Pioneering

Profile of W. Bennett Lewis

By Carell B. Johnson

Last July 26 the quiet library of the Chalk River Nuclear Laboratories was invaded by the bustle of a media event. That afternoon Dr. Wilfrid Bennett Lewis, who had directed the Canadian nuclear research program from 1946 to 1973, received the prestigious Enrico Fermi Award from the U.S. Department of Energy. Only the second Canadian to receive this honour, Lewis was the first to accept it outside the U.S., a concession to his frail health.

Ken Davis, Deputy Secretary of the U.S. Department of Energy, presented the gold medal, cheque for $25,000 and presidential citation to "W.B. — one of the pioneers in nuclear physics and nuclear energy development for almost 50 years."

In response, Lewis paid tribute to the scientists and engineers, many of whom were present, who were also honoured by the award which was being conferred, he noted, in the 50th anniversary year of the discovery of the neutron.

In fact, 1982 was a milestone year in Canadian nuclear history in many ways, marking the 35th anniversary of the NRX reactor, the 25th anniversary of the NRU, and a total of 100 years of operation by CANDU reactors in Canada.

W.B. Lewis' career not only spanned but critically influenced all these events in a variety of ways reflecting his wide range of interests and abilities. As McGill's Rutherford Professor R.E. Bell once said, "Any of us would be happy to be a leader in either academic research or electronic development, or the economic applications of science, or scientific administration, or international co-operation. Wilfrid Bennett Lewis has been a national and world leader in all these fields."

Worked under Rutherford

Born in Cumberland, England on June 24, 1908, Lewis was educated at Clare House Preparatory School, Kent; Haileybury College, Hertford; and Gonville and Caius College, Cambridge. His academic degrees from Cambridge were B.A. (Hons), 1930; M.A., 1934; and Ph.D., 1934.

As a child he enjoyed long hikes with his father, a surveyor, and by the age of 12 Bennett had decided to be an engineer. By 14 his sights were set on physics, but the early interest in measurement was to remain a major theme in his multi-faceted career. According to Dr. Hugh Carmichael, a fellow physicist with Lewis at Cambridge, and a Deep River friend and colleague for 37 years, "The activity in physics that gave Bennett the most satisfaction was probably the instrumentation."

As a research student under Lord Rutherford at the Cavendish Laboratories in 1930-34, Lewis worked on the first use of accelerated particles for producing nuclear reactions. The excitement of pure research at this famous lab, where Chadwick discovered the neutron, was even then tempered with a sobering awareness of world developments. Lewis recalls Rutherford as "very active and concerned about the future and what was happening in German science which was under a cloud."

From 1934 to 1940 Lewis was a research fellow at Gonville and Caius College, working with Dr. J.D. Cockcroft on nuclear disintegrations by particles accelerated by high voltages and, later,

on the construction and operation of the Cambridge cyclotron.

During this period Lewis was one of the first to use electronic amplifiers and binary scalers in nuclear research, and by 1942 he had published a book on this pioneering work, *Electronic Counting*.

Lewis' dedication to work was already evident. "He spent all his time either in the lab or serving as a member of the local unit of the Officers Training Corps," Carmichael remembers.

"At that time Lewis was very interested in electronic field signalling, developing transmitters and receivers for use outdoors. As war came near, he spent most of his spare time with the army."

When war began Lewis joined the Telecommunications Research Establishment. "We just got the Cambridge cyclotron operating in early 1939 and had one paper out on our work," he recalled, "when the government asked Cambridge to loan two men to the Air Ministry. I went along to work on radar."

By 1945 he was chief superintendent of the organization and his wartime work was officially recognized by his appointment as Commander of the Order of the British Empire in 1946 and the award of the American Medal of Freedom with Silver Palms in 1947.

To Chalk River, 1946

In September 1946, when he was 38 years old, W. B. Lewis arrived in Canada to succeed Cockcroft as the Director of Atomic Energy Research at Chalk River. "We were building NRX then," said Lewis, "and one of our first problems was to build a plant to process fuel."

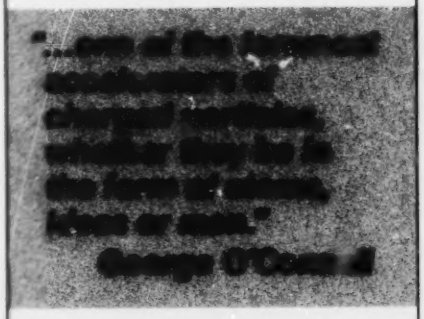
Lewis tackled both the scientific and management challenges of the new job with zest, studying all areas of reactor design, recruiting excellent scientists and expanding laboratories and equipment. A voracious reader and student of pure science, Lewis soon became known as "the one who carries two briefcases." His detailed interest and knowledge in many aspects of the research, including physics, chemistry, metallurgy and biology made it possible for him not only to direct but also inspire projects.

In 1947 Chalk River made nuclear history with the start-up of NRX and Lewis captured the adventurous mood of the early months of the reactor's operation in an article for *The Bulletin of the Atomic Scientists:*

> "We were facing a scale of operation beyond all our experience. Low-power heavy-water reactors had worked, but the NRX was a step into the unknown . . . We were like troops facing their first battle."

Typical of his comprehensive view that ranged both within and beyond the lab, Lewis' involvement in the immediate technical challenges of bringing NRX to full power by 1948 was combined with planning for the reactor's long-term potential. Chalk River associates credit the director with recognizing, more than most, the great research opportunities provided by NRX and effectively exploiting them.

When NRX suffered a serious accident in 1952, Lewis' leadership sustained the morale of those who feared that the reactor and Canadian nuclear research were doomed, and organized



reconstruction to produce a better, more powerful reactor.

After the accident, recalls Dr. George C. Laurence, the eminent Canadian physicist, "The immediate reaction of the staff was — 'It looks like this is the end.' But Lewis took it all in his stride. He called the staff back to the site within a few days, got us to work cleaning up the mess, and began reorganizing and planning for the future. He seemed to just take it for granted, and that settled the question."

Lewis was also a prime catalyst in the decision to build NRU, then the most powerful and still the most versatile research reactor in the world. By the spring of 1949 the Director was arguing, in a then secret progress report, that "since it is to be expected that eventually the NRX reactor will fail," there was a need for a second reactor which could help pay for itself by producing a valuable commodity for export to the U.S. — plutonium.

Reflecting back on this period, Lewis has said, "It's strange how things all mesh together. In 1951 I was able to give a paper saying that our basic reactor design could give a sufficiently long period of irradiation to produce power."

Community interests too

While research paths were being blazed at Chalk River, five miles up the Ottawa River the village of Deep River was being carved out of the bush as a residential community for the scientists. Like all single Chalk River staff in those days, Lewis was initially housed in dormitories constructed largely by prisoners of war.

Colleagues recall him as an active resident of the staff hotel, attending all the concerts, plays, picnics and other social events organized by the small community.

But "W.B." showed no inclination to change his bachelorhood status, and when he moved from the hotel to a house, his widowed mother came over from England to housekeep for him. When family friends argued against his plan, saying Bennett might marry if left on his own, and this would be "good for him," Mrs. Lewis replied, "Never. He's married to his work."

Lewis did find time for some recreation, however, and soon became a charter member of the Deep River Yacht & Tennis Club. Fellow members say he was an enthusiastic but average competitor in the weekly Y-Flyer races, sailing "with a mechanical precision."

In his limited spare time he also enjoyed curling, hiking and wildlife observation. A birdwatcher's guidebook accompanied weekend strolls and drives, for even in leisure "W.B." relished accuracy. And if he were in town, Sunday mornings always found him in the front pew at St. Barnabas, the local Anglican Church to which he had donated generously over the years.

But Lewis' major community interest has been the development of the local library into one of the best small town facilities in Canada. In 1947 he became chairman of the Deep River Library Board, a position he held for 35 years.

Librarian Irene Cox describes him as a "superb" and innovative chairman who "kept up with the times remarkably. Board meetings never had a definite date, as Dr. Lewis always insisted on being there. Sometimes it was a matter of fitting a day between world trips."

Lewis was the first to suggest the

Lewis receives the prestigious Enrico Fermi Award from then U.S. Deputy Energy Secretary Kenneth Davis (left) at Chalk River ceremony.

library branch out into records and video equipment, and instigated the setting up of reading rooms in local rural communities. A book lover himself, with Victorian literature and Sayers' "Peter Wimsey" series among his favourites, Lewis strongly believed everyone should have access to knowledge.

AECL Vice-President, 1952

While the young village of Deep River was busy organizing cultural and recreational activities for its cosmopolitan residents, the Chalk River labs were undergoing basic reorganization. In 1952 their administration was transferred to the newly created Atomic Energy of Canada Limited, and Bennett Lewis became its Vice-President, Research and Development.

That same year J. Lorne Gray was appointed general manager at Chalk River and he and Lewis were to prove an effective combination for promoting and developing AECL policies. Gray, who became a Vice-President in 1954 and the company's president in 1958, once said that the job of gaining government support was made much easier by the early groundwork done by people like Lewis; — "Besides, Lewis is such a thorough scientist and is backed by such a good team that it's easy to fight for a gang like that!"

By 1952 the construction of NRU, which was to begin operation in 1957, was well underway and Lewis was spearheading programs which would lead ultimately to the design of the CANDU reactor.

His 1951 "Atomic Power Proposal" reasoned that nuclear energy could be brought "in a limited form, into possible economic competition with coal as applied to large steam-driven electrical generating plants."

CANDU takes shape

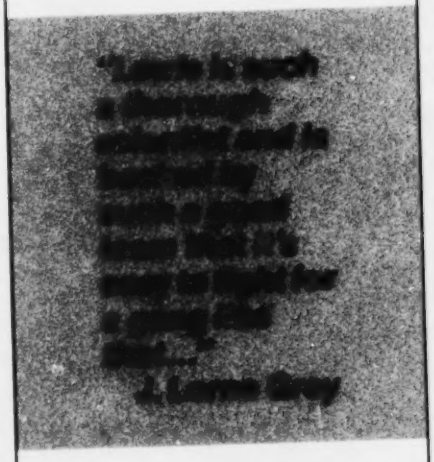
But before commercial nuclear plants could become a reality there were major technical problems to be solved, especially in the effects of neutron radiation on materials. With energy and persistence Lewis organized and participated in the research that led eventually to the CANDU reactor design. Dr. Ken Hare, Provost of Trinity College, University of Toronto, sums up the theme of many award speeches when he says: "The CANDU reactor would not exist if it weren't for Bennett Lewis."

During this early stage of reactor design Lewis was looking ahead to the day when there might not be enough natural uranium to fuel reactors. He conducted enough assessment studies on fuel reprocessing to establish its feasibility, but suspended the work when experience with NRX showed that natural uranium (in the form of uranium oxide) would allow a sufficiently high burn-up to make a once-through cycle economical.

In 1954 a nuclear power branch, headed by Harold Smith of Ontario Hydro, was established at CRNL and a feasibility study was undertaken before the new branch launched into the preliminary design of the NPD reactor. That same year AECL, Ontario Hydro and Canadian General Electric formed a partnership to build the proposed plant, and Lewis played a key role in coordinating the joint effort.

Turned on its side

Lewis was also among the first to recognize the advantage of pressure tube reactors and in 1957 had the foresight to recommend AECL make one of the most dramatic and far-reaching decisions in Canada's industrial history — the switch from what became known as the NPD-1 design, a



vertical pressure vessel reactor, to the NPD-2 system, a reactor with horizontal individual pressure tubes.

When Harold Smith recommended the design in a 1957 report, after his engineering team had explored several options, Lewis immediately recognized the importance of the concept and asked AECL to halt construction of the demonstration plant and redesign the reactor so that it "be turned on its side".

Without this basic design change NPD could not have become a true prototype of future CANDU reactors, for it would have been very difficult to make larger pressure vessels for commercial-scale plants in Canada.

This critical 1953-57 period in the nuclear power program was summarized by Lewis in a 1959 paper:

> "We had seen potential advantages of pressure tube reactors, but it remained for Harold Smith's team later to begin to trust Zircaloy pressure tubes, turn the tubes horizontal and so add the benefits of bi-directional fueling and long burn-up. All features of the design found support in work already carried out at Chalk River in uranium dioxide fuel, zircaloy cladding, moderator-level control and so on. So great did the advantage appear that in 1957 we changed NPD to this style from our original concept of using a pressure vessel."

In this new design the reactor fuel was contained in relatively short 20 inch horizontal bundles rather than in one long vertical element, as in NRX and NRU. The great advantage was that these bundles could be fed fresh from one end of the tube and then moved progressively along through the reactor core. By the time each bundle reached the other end it would be fully burned up, thus keeping fuel cost at a minimum.

The new system also allowed for advancing fuel in alternate channels (bi-directional fuelling) which made it possible to maintain a uniform flux pattern of power output along the length of the channel. This uniformity of power output, in turn, helped maintain the reactor at its full power rating.

The technical innovation which made the design change possible was the development of Zircaloy pressure tubes. This new alloy of Zirconium, with its low neutron absorption, would capture few neutrons released during the fission process.

Construction work on NPD-1 was halted early in 1957, while re-design work was undertaken, and by 1958 construction of NPD-2 began. The station was completed in 1962 and criticality was achieved April 11. By Nov. 25, 1963, NPD became the world's first power reactor to achieve on-power refuelling.

In 1959, while the redesigned demonstrator reactor was being built at Rolphton, the federal cabinet approved the construction of a commercial-scale CANDU plant, and Douglas Point was chosen as the site.

The next year AECL presented to parliament a policy and programs brief which included a comprehensive review by its crusading Vice-President on the nuclear power possibilities for the whole of Canada. Lewis summarized the multitude of variables which made energy policy planning such a challenge, and championed the merits of pushing ahead with nuclear power plants. The CANDU reactor, with a heavy water moderator and natural uranium fuel, was being designed to achieve "very low fuel and operating costs" as compared with the cheapest conventional fuel plants in Ontario. If

(continued on page 44)

PRECISION
RELIABILITY
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MAINTAINABILITY

Four basic reasons why Newman Hattersley Bellows Sealed Valves are high technology's first choice.

For thirty years Newman Hattersley and its associated company, Hattersley Heaton, have been manufacturing precision, nuclear class, bellows sealed and check valves for Canada's Candu reactors, as well as other reactor designs, produced throughout the world.

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BETTER BY DESIGN

(continued from page 42)

between a third and a half of Ontario's 1980 energy needs could be met by nuclear power. Lewis predicted that "a saving of $100,000,000 to $2,000,000,000 a year in foreign exchange would result.

Seven in the top ten

Twenty-one years later in his acceptance speech for the Fermi Award, Lewis was able to proudly announce that "of the world's 131 power reactors of 500 megawatts or more capacity, ranking them by lifetime performance places CANDU reactors in seven of the top ten places."

In 1963 W.B. Lewis was appointed Senior Vice-President (Science) of AECL and in the decade until his retirement, he continued to promote the Canadian nuclear reactor system all over the world, while at home the Pickering station was built and brought into operation.

During this period Lewis focussed on future systems of energy production which could develop out of CANDU reactors, studying the organic-cooled CANDU alternative and the thorium cycle, which would increase the fuel supply for CANDU-type reactors manyfold.

Another major project initiated by Lewis in the sixties was research on the spallation nuclear reaction. This work culminated in the 1966 "ING Report", a proposal that AECL build an Intense Neutron Generator.

Lewis and others at Chalk River believed that the intense beam of high energy nucleons from "ING", a special type of accelerator, could be used to "boil off" neutrons from heavy nuclei, producing a greater intensity of neutrons than in a nuclear reactor for a comparable cost. These high intensity neutrons would be valuable for research.

In 1968, however, the federal government turned down AECL's request for funds for the ING project, and Lewis was extremely disappointed. The proposal was rejected as being too expensive, in view of competing pressure for funds from university projects. Despite this setback, research in accelerator breeding has been kept alive in Chalk River's Accelerator Physics Branch.

Back to academia

After retirement from AECL in 1973 Lewis moved to Kingston, his base for the next nine years while he lectured and wrote on nuclear energy as a distinguished professor at Queen's University.

During these years Lewis remained active in international organizations. Specific appointments have included 21 years on the International Atomic Energy Agency's Scientific Advisory Committee, and service as the Canadian Representative on the U.N. Scientific Advisory Committee. A Charter member of the American Nuclear Society from 1955, he became the Society's President in 1961. Lewis is also a member of an informal group based in Ontario, Quebec and the northern States — "The Friends of Climatology." At the annual meetings of this group, established in 1968 to study the impact of climate on world problems, he has emphasized the dangers of carbon dioxide build-up in the atmosphere, due to the burning of fossil fuels.

Always interested in the practical applications of modern technology for the benefit of society, Lewis was an eloquent prophet of optimism during the energy crisis of the seventies, scorning what he called "the doom and gloom and fear-mongering societies and the backward dreaming such as the Friends of the Earth and the Sierra Club."

Far from being on a downhill slide to freezing in the dark, Lewis argued, mankind could take a qualitative leap "from survival to superliving" if it would only co-operate in confidently exploiting the potential of low cost nuclear energy from the thorium cycle.

The conclusion to Lewis' 1977 paper, "Harnessed Energy against Starvation" summarizes the theme of many lectures at home and abroad:

> "There is abundant energy that can be harnessed from nuclear fission without fast breeder reactors, with less man-hour effort and risk than has ever been achieved, except for a few, to provide food, warmth, fresh water, clean air, travel, communication, inspiring work, gardens, sports, shows, leisure, etc., for all the world's population for thousands of centuries. No technical breakthrough is lacking, it is only habitual selfish distrust of others that limits the scale on which we now cooperate. Pickering has shown the way."

Numerous honours have come to W.B. Lewis over the years, including many honorary D.Sc. and LL.D. degrees from universities. In 1966 he received the first Outstanding Achievement Award of the Public Service of Canada and in 1967 he shared the Atoms for Peace Award with another scientist. The Royal Society (London) awarded him its Royal Medal in 1972. In 1973 the Canadian Nuclear Association struck a medal in his name, to be awarded annually for an outstanding contribution by a Canadian in the field of nuclear science and engineering. Lewis was delighted with the announcement that the first recipient was Harold Smith.

Poor health following a collapse in February, 1982, just one day before the Fermi Award announcement, led to Lewis' full retirement later that year and he now lives in Deep River with his sister. He still attends all board meetings for "The W.B. Lewis Library" however, and is well remembered as "one of the foremost accelerators of charged particles, whether they be in the form of atoms, ideas or men." (George O'Connell, Dartmouth College) ■

RADIOISOTOPES

(continued from page 39)

ployed as a tracer to find groundwater contamination from sewage disposal systems.

In Quebec, the growth of pork farming has necessitated regulation of management, handling and storage of liquid animal wastes. Large tanks, up to a million gallons, meet storage requirements but frequently develop leaks releasing pollutants into the groundwater system. There is a need for a reliable, reproducible and economical technique to identify these leaking tanks, and water sampling and the use of conventional chemical and bacteriological analyses applicable to this type of pollutant have proven to be unsatisfactory for the conclusive identification of failed tanks. Radioisotopes as tracers have been proposed as an effective method of identifying leaking tanks, and evaluating new tank materials and construction methods.

Uses in fundamental research

As tracers, isotopes are immensely powerful in unravelling nature's systems. Their use has yielded much information about the complex construction of living cells and their generic material. They are essential tools in molecular biological research. More than 50% of the carbon-14 used worldwide in labelled compounds for biological, pharmacological and medical research is produced in Canada by RCC.

Other areas

In addition to these areas isotopes, particularly Co-60, are very widely used as large sealed irradiation sources for cancer therapy, medical product sterilization and radiation processing of various materials. This technology is also showing excellent prospects of widespread use in food irradiation and waste sterilization. ■

Fifteen common questions about AECB

Based on a paper by N. S. Blackman
and W. K. Gummer, AECB

ABSTRACT
An overview of the responsibilities and activities of the Atomic Energy Control Board including questions often asked concerning the role of the AECB, its organization, licensing and compliance activities, and communications with the public.

What is AECB?

The Atomic Energy Control Board is the federal regulatory body which supervises and controls the health, safety and security aspects of nuclear energy in Canada.

It is also responsible for the administration of the Nuclear Liability Act, including the designation of nuclear installations and prescription of basic insurance to be carried by the operators of such designated nuclear installations. AECB was established in 1946 by the Atomic Energy Control Act.

How is the AECB organized?

The five-member Board consists of four members who are appointed by the Governor in Council and the President of the National Research Council as *ex officio* member. One of these members is appointed President and Chief Executive Officer, and is currently the only full-time member of the Board.

Present membership is as follows:

Mr. J. H. Jennekens,
President and Chief Executive Officer

Dr. L. Kerwin, *(ex officio)*
President of the National Research Council

Miss S. O. Fedoruk
Director of Physics
Saskatchewan Cancer Foundation
and
Professor of Oncology
University of Saskatchewan

Mr. J. L. Olsen
President and Chief Executive Officer
Phillips Cables Limited

Professor P. Marmet
Professor of Physics
Université Laval

The day-to-day regulatory operations of the AECB are carried out by a scientific, technical, and administrative staff of 230, the majority of whom have scientific and technical backgrounds. The diagram shows the structure and individuals in key positions.

The AECB receives advice and cooperation from other federal departments and agencies and from provincial governments that assist it in its licensing and compliance inspection activities. The AECB also sponsors certain Advisory Committees with relevant expertise from the federal and provincial governments, and the academic and other private sectors, who advise the AECB on matters related to its regulatory activities. At present there are committees on Radiological Protection, Nuclear Safety, and a Subcommittee on Nuclear Security (formed under the federal government's Security Advisory Committee). Membership in the first two committees is entirely from outside the AECB.

What are staff functions and organization?

The *Secretariat* embraces the staff functions of Secretary to the Board, Office of Public Information and the Medical, Science and Special Advisers to the AECB.

The *Legal Adviser*, seconded from the Department of Justice, and the *Official Languages Adviser*, report directly to the President.

The *Directorate of Reactor Regulation* is responsible for the safety evaluation, quality assurance, licensing (including operator examination and certification), and inspection of all nuclear power plants, research reactors and accelerators.

The *Directorate of Fuel Cycle and Materials Regulation* is responsible for the safety evaluation, quality assurance, licensing and inspection of uranium mines, uranium refineries and conversion facilities, nuclear fuel fabrication plants, radioactive waste management facilities, heavy water plants, and users of radioisotopes and prescribed substances.[1] The Directorate is also responsible for provision of laboratory services and for the implementation of domestic and international nuclear material safeguards programs.

The *Regulatory Research Branch* is responsible for the management of mission-oriented research programs designed to provide information for use in the regulatory functions, and for the production of regulatory documents. It is also responsible for the assessment of radiation hazards and protection programs for licensed activities, and for the development of related standards and guidelines.

The *Planning and Administration Branch* is responsible for such centralized administrative functions as office services, registry, library, personnel and finance, and planning and coordination.

---

1. Uranium, thorium, plutonium, neptunium, deuterium, their respective derivatives and compounds and any other substance that the Board may, by regulation, designate as being capable of releasing nuclear energy or as being requisite for the production, use or application of nuclear energy.

How does the AECB "administer" nuclear matters?

The AECB controls all dealings in prescribed substances and equipment for the purpose of assuring health and safety, and national and international security. Cooperation is received from other federal and provincial government departments and agencies in the areas of health, safety, environment, transportation, labour aspects, etc.

What is implied by "Licensing System"?

AEC Regulations require that a licence from the AECB must be obtained by any person or organization wishing to mine, refine, process, or use prescribed substances, to export such substances or equipment, or to operate a facility for the production of deuterium oxide (heavy water), or nuclear energy. Before issuing a licence, the AECB requires from the person or organization sufficient information to show that required health and safety standards will be met and maintained, and that any wastes will be managed in a satisfactory manner.

In order to exercise its regulatory role, the AECB establishes standards that must be met; assesses potential licensees' capabilities to meet these standards and to assure their maintenance; and, once a licence is issued, carries out compliance inspections to ensure that its requirements are continuously met.

What are the licensing activities of the Board?

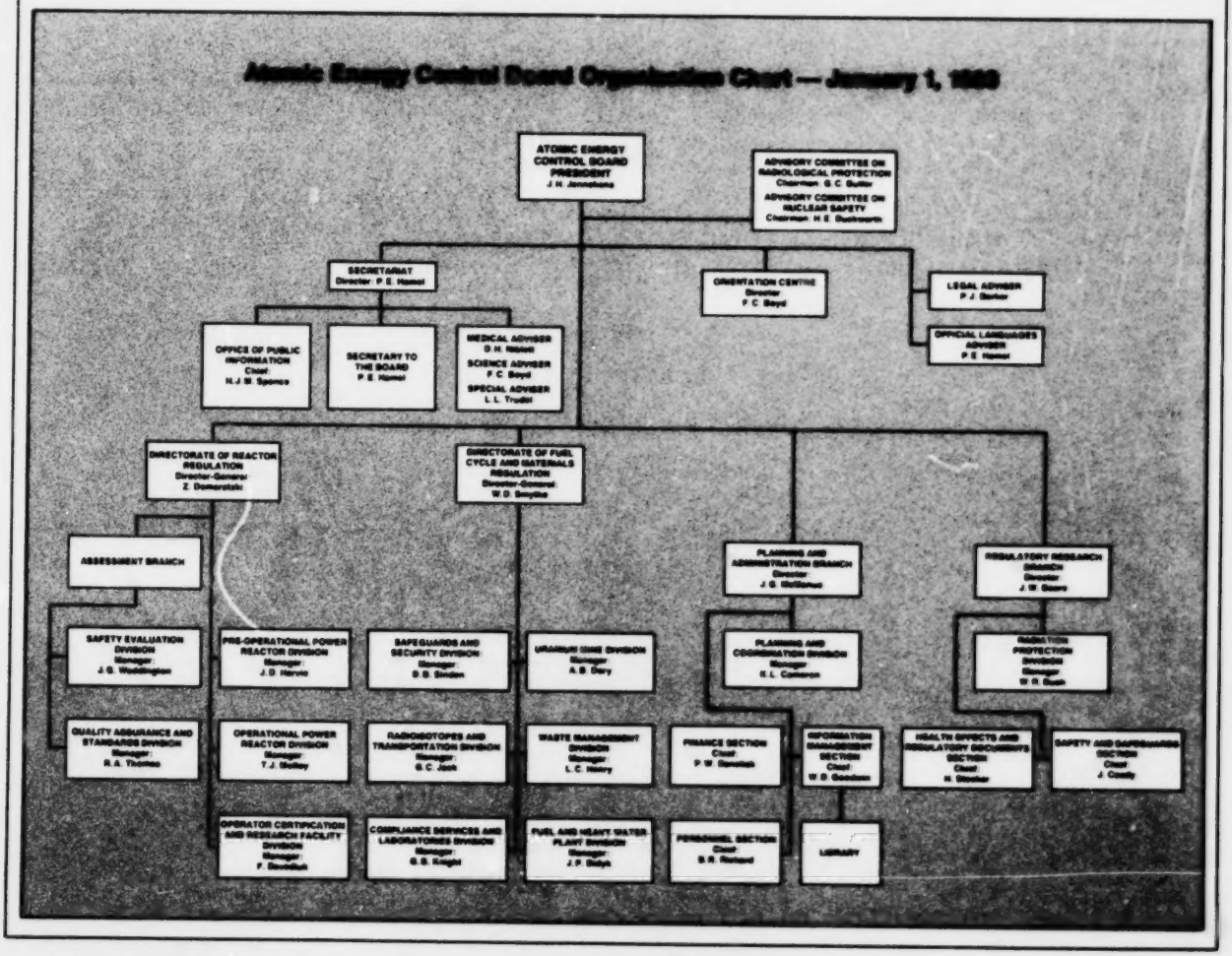
The process of licensing uranium mines and mills, refining and conversion facilities, fuel fabrication facilities, heavy water plants, nuclear power reactors and radioactive waste management facilities, takes place in three phases, the end-point of each being marked in turn by the AECB issuance of a) site acceptance, b) construction approval, and c) an operating licence. Although the end-point of each phase is clearly delineated, the activities that lead up to these points overlap. Thus, activities which are relevant to an application for an operating licence can commence before either the construction approval or site acceptance is issued.

Is exploration activity licensed by AECB?

While exploration for uranium and thorium is regulated by the province, the AEC Regulations require that a federal permit be obtained when the ore grade exceeds 0.05% and it is intended to remove more than ten kilograms of uranium or thorium in any one calendar year. If only surface removal is to be carried out, an Ore Removal Permit is required. Where extensive stripping, work shafts, and drifting into an ore body are to occur, an Underground Exploration Permit is required.

What other licences are issued by AECB?

Subject to minor exceptions, any person wishing to own, use or sell a prescribed substance must obtain a licence that is issued if the AECB is satisfied that the substance will be used and disposed of safely. Two types of licences are issued: prescribed substance licences covering uranium, thorium and heavy water; and radioisotope licences covering certain radioisotopes for use in medicine, for diagnostic and treatment purposes.



and in industry for radiographic inspection, process control, static elimination, oil well logging, etc. A common use is in consumer products such as smoke detectors and watches. These are generally exempted from licensing because of the minute quantities involved, however each model must be approved by the AECB prior to distribution.

As with nuclear facilities, when the AECB issues a prescribed substance licence or radioisotope licence, it specifies the conditions that must be met by the user and it carries out an inspection program to check compliance by the licensee.

How does AECB ensure security?

The control of prescribed substances and equipment to assure the non-proliferation of nuclear explosives is effected by licence conditions and by controlling the import and export of substances and equipment. This is done in cooperation with other federal government departments and agencies. International safeguards provisions of the Treaty on the Non-Proliferation of Nuclear Weapons are administered under a safeguards agreement with the International Atomic Energy Agency which provides for the inspection of the Canadian nuclear program by that Agency.

What controls on transport of radioactive materials?

The transportation of radioactive material is subject to regulation by the Canadian Transport Commission (shipment by rail), the Air and Marine Administrations of Transport Canada (shipments by air and sea respectively), and the National Harbours Board and the St. Lawrence Seaway Commission (shipments through ports and the Seaway). In the absence of any specific provisions governing shipments by road, the CTC (Rail) Regulations have been made applicable and are administered directly by the AECB for road transport.

The AECB regulates the shippers of radioactive material and hence the type of container in which the material is transported. For small quantities of radioactive material the design of the container need only meet certain performance standards specified in the Regulations. For larger quantities a certificate authorizing the use of a specific package (or container) is issued once it has been shown to meet the standards established by the AECB.

A Memorandum of Understanding is in place to govern the various interfaces of the AECB and Transport Canada concerning the transportation of radioactive materials.

What are the AECB "compliance activities"?

An important activity of the AECB is to ensure that once a licence has been issued to a person to operate a nuclear facility, or to use or possess a prescribed substance, that person complies with the conditions of the licence and with the requirements of the Regulations. This is accomplished in five ways:

(a) AECB staff members are located at nuclear power reactor sites as well as in the Elliot Lake mining area. Their full-time role is to carry out inspections and maintain constant surveillance over the licensed facilities.

(b) AECB staff, based at Head Office, visit licensees across Canada to carry out inspections.

(c) There are two AECB regional offices — in Mississauga, Ontario, and in Calgary, Alberta — with inspectors who cover Southern Ontario and Western Canada.

(d) The AECB augments its inspection capabilities by the appointment, with approval of senior provincial ministry officers, of members of provincial departments to act as inspectors for the Board.

(e) It is also a requirement of licensees that they make periodic reports to the AECB and report any abnormal occurrences.

The AECB maintains a laboratory in Ottawa for carrying out radiochemical analyses of samples taken during inspections as well as other analyses which might not be readily obtainable elsewhere at short notice.

The AECB also sponsors a twice-a-year training course for uranium mine inspectors (including personnel from uranium mining companies and labour unions, as well as federal and provincial agencies). Currently these programs are offered at the Canadian Institute for Radiation Safety, Elliot Lake, Ontario.

What does "joint regulatory process" mean?

This describes the working arrangements the AECB has with other federal and provincial regulatory departments and agencies that have mandates in occupational health and safety and environmental protection. The objective of these working arrangements is to satisfy concerns that federal and provincial requirements are met in the licensing of nuclear facilities, and to avoid duplication. The AECB carries the lead role in this joint process.

What access is there to AECB licensing information?

Subject to a limited number of exemptions, all information supplied to the AECB in support of licence applications, final staff recommendations to the Board, and all documents incorporated into or forming part of a licence are made available to the public.

The AECB reports to the public through the news media at all steps of the licensing process for nuclear facilities, whenever significant hazards exist or may develop, and at any time that significant occurrences result in corrective measures being taken or ordered.

A public documents room has been provided at AECB Head Office in Ottawa where documents relating to licensing information may be viewed by the public.

What other communications methods are employed?

AECB's communication with the public may also occur by means of:

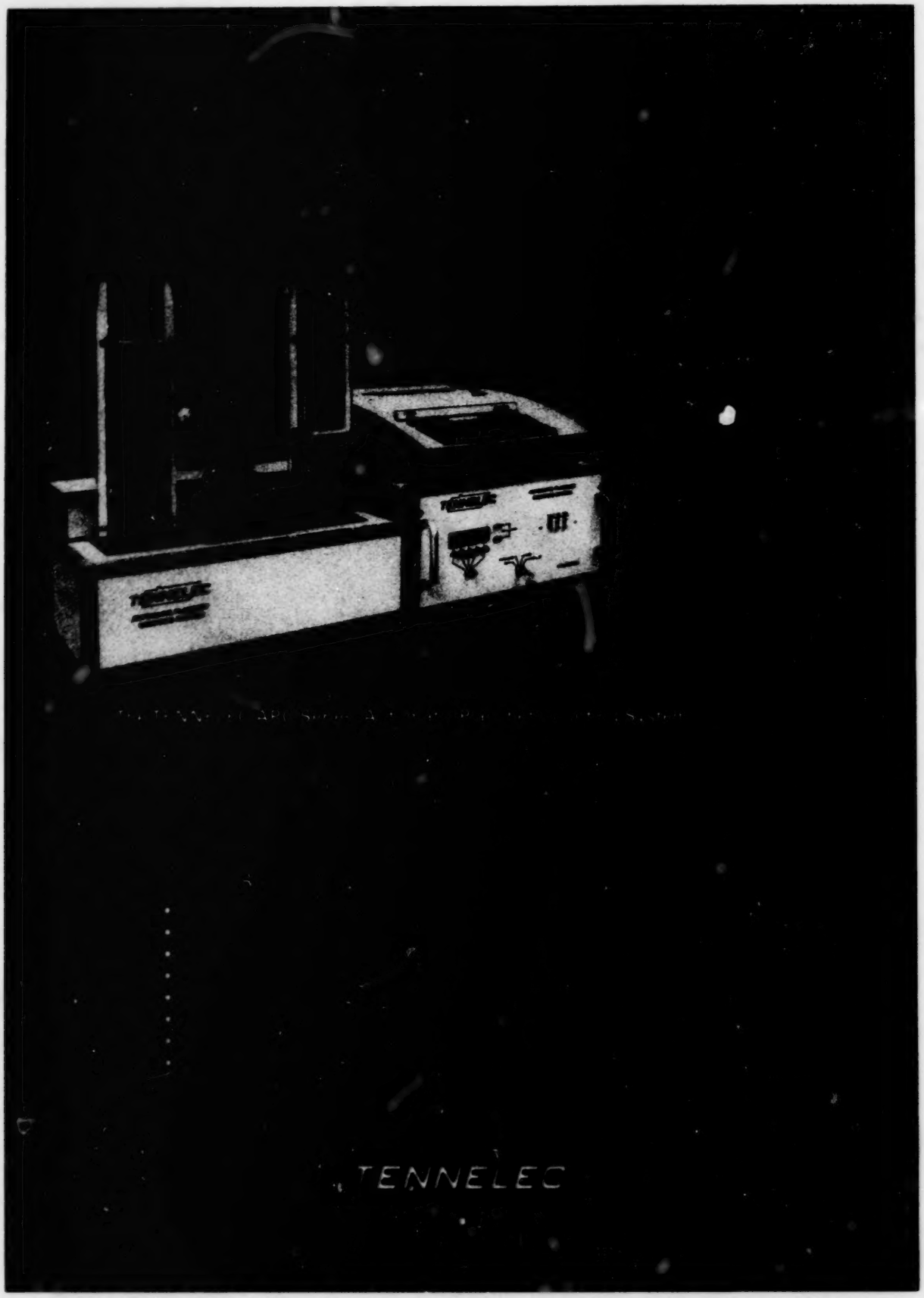
- documented representations to and, in certain cases, appearances by interested parties before regular meetings of the five-member Board;
- presentations by the President and AECB staff before public meetings, Royal Commissions, and government committees to explain Board policies, criteria, and activities;
- a Consultative Document System whereby drafts of all proposed documents of a regulatory nature, including revisions to Regulations, are made available for public comment. As the Office of Public Information maintains open mailing lists, copies of such documents are automatically sent to interested parties, soliciting comments;
- news releases and information bulletins are mailed on a routine basis describing licensing actions and other regulatory information;
- oral and written announcements on matters of public interest;
- a Publications Catalogue is available free, upon request.

Want to know more?

Further information on any of the AECB's regulatory activities may be obtained by contacting the Office of Public Information at (613) 995-5894, or by writing to:

Office of Public Information
Atomic Energy Control Board
P.O. Box 1046
Ottawa, Ontario
K1P 5S9

The AECB Public Documents Room is located in the Martel Building, 270 Albert Street, Ottawa, Ontario. ■


TENNELEC

An Overview of Public Opinion and Nuclear Issues

M. Barrados and M. Binns, Corporate Public Affairs,
Atomic Energy of Canada Limited

Over the period that public opinion toward the use of nuclear power to generate electricity has been monitored in Canada, a great deal of variation in support and opposition levels has been found. See Chart 1. The past year is notable because of the drop in the proportion of Canadians who had no opinion and the increasing levels of opposition. Only at one other time, after the accident at Three Mile Island, have more Canadians been opposed than in favour of the use of nuclear power to generate electricity.

Decisions about nuclear power issues related to the generation of electricity are not a high priority for most Canadians. Canadians feel that the most pressing issues facing them are related to unemployment and inflation. Only 2% of Canadians consider energy issues as most pressing. As a subset of energy issues, nuclear energy was only mentioned directly by 1% of Canadians as most important.[1] The most important energy issues were felt to be related to cost, shortages of energy supply and problems related to energy sources other than nuclear.

In addition to not being an issue high on the public policy agenda, many of the views expressed about the use of nuclear energy are not strongly felt:

Opinion about the use of nuclear power[2]

12% strongly in favour
30% somewhat in favour
21% somewhat opposed
30% strongly opposed
7% don't know

Weakly-held views are the most subject to sudden shifts as information related to nuclear power generation and related issues appear in the popular media. The greatest change in public opinion is likely to occur among Canadians who hold qualified views.

The increased negativism in public opinion found in the past year is particularly marked because of the increase in strongly held negative views. The greatest change occurred in the increase in the proportion of Canadians who felt they were strongly opposed to the use of nuclear power to generate electricity.

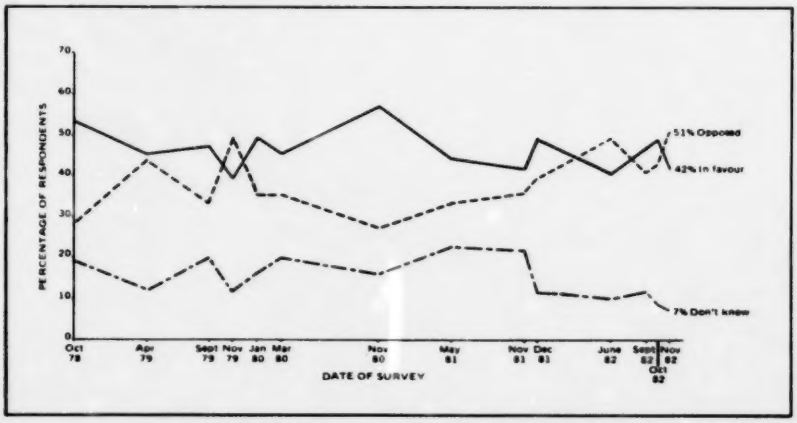


Chart 1: Opinion About the Use of Nuclear Power for the Generation of Electricity

Basis for Shift in Opinion

As can be seen from Chart 1, twice during the past year, in June and November, public opinion surveys showed marked increases in negative responses. A number of factors may have influenced these shifts in opinion. There were no power generation events, such as a major accident, in the news that could have resulted in such a negative swing in opinion. It appears that increasingly non-nuclear power generation issues are influencing public evaluations on the use of nuclear power to generate electricity.

The increases in negative opinion were associated with a marked shift in news coverage of nuclear issues to stories on war, nuclear weapons, and nuclear disarmament. Coverage of nuclear issues, nationally, also focussed on the difficulty of marketing reactors internationally and political issues associated with specific international markets, for example the shipment of fuel to Argentina during the Falklands war. There was very little coverage of positive developments or achievements in the industry in the national media.

Throughout the past year, reports of electricity surpluses and dropping oil prices raised doubts about the immediate need for nuclear power generated electricity. In September, half of the Canadians polled believed the energy shortage never existed, but rather that it was contrived for political or economic reasons. Table 1. A strong publicly-viewed case for nuclear power is based on the argument that it is a needed power source in times of diminishing supplies of oil and gas. This position appears to have been weakened in the shorter term by events in the international oil markets.

Continuing economic pessimism has negatively influenced Canadian views on many issues including the use of nuclear power. In November, three-quarters (76%)[3] of Canadians inter-

TABLE 1: Canadian Views of Energy Supply - September 1982

There is a very real energy shortage and the problem will get worse during the next five to ten years.	23%
There is a real energy shortage but it will be solved in the next year or two.	11%
There was a short-term problem, but it has been largely solved and there is no real problem any longer.	11%
There never was any real energy shortage, it was contrived for economic or political reasons.	52%
Don't know	4%
	101% (2014)

*Question: Here is a list of four statements about energy. Which **one** of these statements comes closest to expressing your opinion?*

Source: The CROP Report: 83-1, February 1983.

viewed by CROP believed that unemployment would increase over the next six months.

An additional factor that may be influencing Canadian public opinion is the rising opposition to the use of nuclear power in the United States. It is difficult to evaluate the extent of this influence but it is no doubt present because of the close mass communications ties with the United States. In November 1982, 54% of Americans polled opposed and 38% supported the building of more nuclear plants in the United States.[4]

The over time trend in Chart 1 reflects the responses to a general measure of opinion about the use of nuclear power to generate electricity. Evaluations of more specific nuclear policies have also tended to show a drop in support, for example, the sale of reactors abroad to countries that agree to use them for peaceful purposes and building nuclear power plants to sell electricity to the United States.

Regional Variations

Over the period that public opinion on nuclear power generation has been tracked, consistent patterns of regional variation have been found. Support has consistently been the strongest in the Province of Ontario, followed by New Brunswick and Saskatchewan. Support levels in these regions have also tended to drop over the past year. Support levels continue to be the lowest in British Columbia and Quebec.

These regional variations reflect in part, the experience each province has had with nuclear power generation or uranium mining, the range of information activities associated with these developments and the profile of the government support given to them.

Public support for nuclear power has also been influenced by the perception of the need for nuclear power as an alternate energy source in the province and its role in contributing to provincial development.

When Canadians were asked in September 1982 to evaluate various factors that could form part of the decision to build a nuclear power plant in their province, favourable opinion was found if such a plant:[5]

- Was used as an alternate source of energy for the production of electricity .....59% in favour
- Contributed to the future development of the province ..... 54% in favour

The strongest support for decisions made on the basis of the need for nuclear power plants as an alternate source of energy was found for respondents in Ontario and New Brunswick. The strongest support for deciding to build nuclear power plants on the basis of their contribution to provincial development was also found in Ontario, followed by Nova Scotia, New Brunswick and Alberta.

In addition to wanting to have the contribution to provincial development and the requirement for additional energy clearly established, Canadians expressed an interest in obtaining further information on many of the issues traditionally associated with nuclear power generation, particularly safety. Before decisions were made about building nuclear power plants in their province, 41% of Canadians wanted more information on safety. Other information interest areas were waste disposal (16%), costs (12%), environmental effects (11%) and location (10%).[6]

Future Role

Many Canadians support the use of nuclear power to generate electricity because they consider it to be a futuristic energy source that may be required to meet longer-term needs. Support for nuclear power generation as an energy source for the future can be seen in the ranking given by Canadians to the sources of additional energy over the next 10 years. Nuclear power was considered to be in the top three, behind solar energy and water from new dams.

Canadians clearly support large projects designed to meet future Canadian energy demands. Over half of Canadians (56%) felt it was very important and a third (35%) felt it was somewhat important for Canada to go ahead with large-scale energy projects.[7]

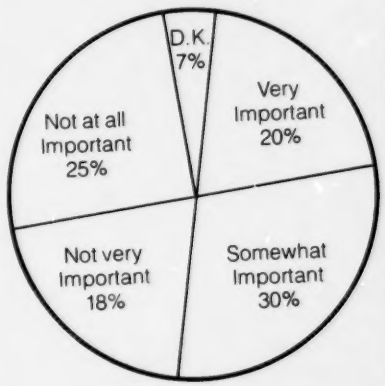
Canadians, however, were divided on whether nuclear projects should be considered in the same way as other large-scale energy projects. This evaluation no doubt reflects some of the issues raised in the more immediate evaluations of the use of nuclear power.

TABLE 2: Favoured Energy Sources over the Next 10 Years — November 1983

Solar Energy	36%
Water Power from New Dam	20%
Nuclear Energy	13%
Oil from Offshore Wells	9%
Oil from Tar Sands	6%
Wind Power	4%
Coal	3%
Energy from Ocean Tides	1%

Source: The CROP Report, 83-1, February 1983.

CHART 2: Importance of Nuclear as a Large-Scale Energy Project — November 1982



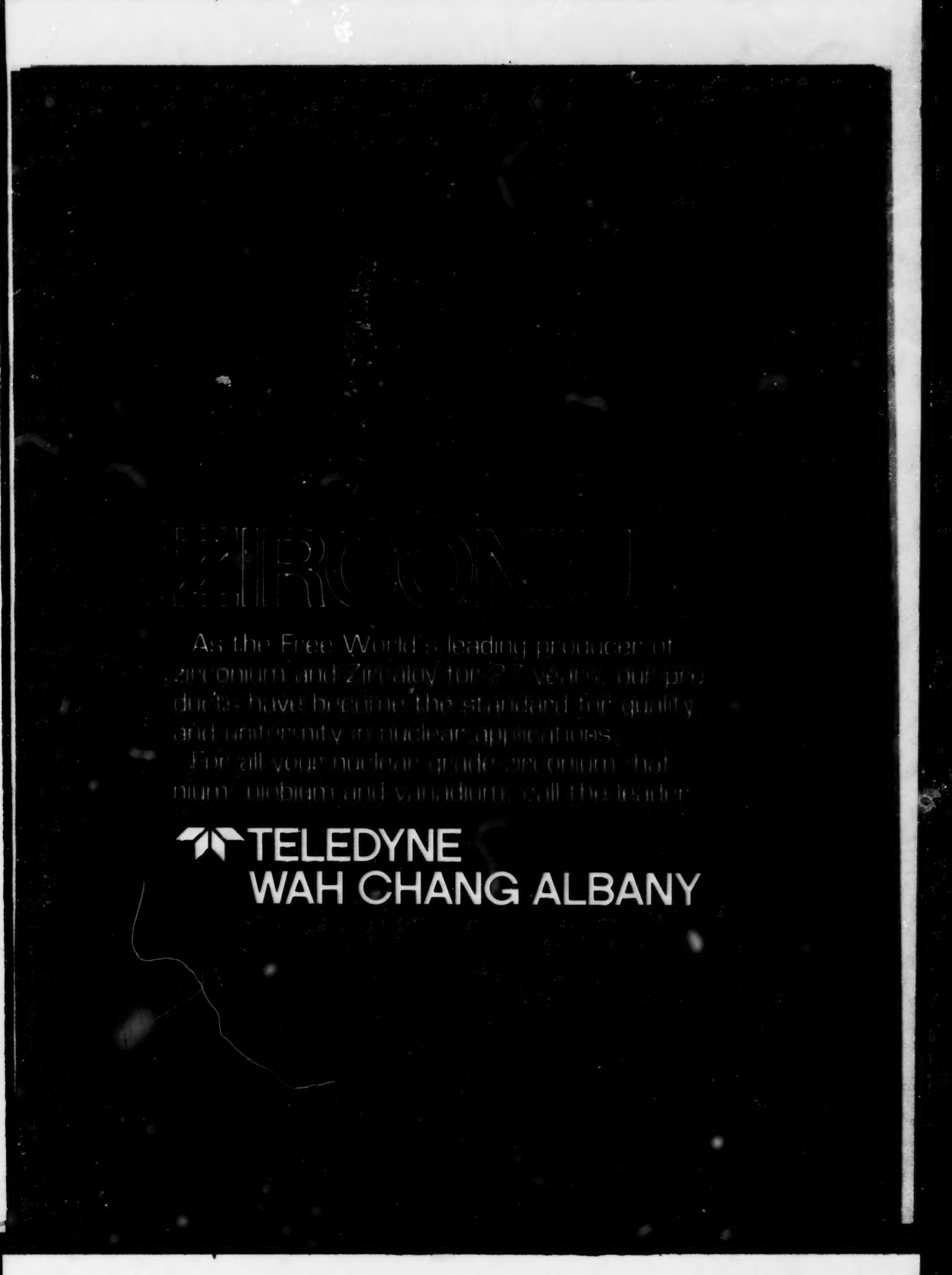
Source: CROP National Omnibus Study, November 1982.

Fifty percent of Canadians attached some importance to including nuclear power projects to generate electricity as a large-scale project. 25% felt it was not at all important. Chart 2. Because of the generally low priority given nuclear energy issues and the persistence of such traditional concerns as safety and waste management, many Canadians have not given the same consideration to nuclear generating stations as other energy mega-projects.

Summary

Nuclear power used to generate electricity continues to be viewed by Canadians as an energy source for the future, particularly to meet possible future energy shortages. In the shorter term, public opinion has become less supportive of nuclear power generation. The shift in opinion has been associated with increased media coverage of nuclear weapons and nuclear disarmament, less concern about energy

(continued on page 61)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WAH CHANG ALBANY

What you should know about the CNA

The Canadian Nuclear Association is a non-profit voluntary membership body, established in 1960, for the purpose of promoting the orderly and sound development of nuclear energy for peaceful uses in Canada and abroad. It operates on an annual budget of about $350,000 and has a current membership of nearly 200 member organizations.

Because of the extreme breadth and complexity of nuclear applications, the "nuclear industry" is not a single, well defined industry, but one composed of many industries and enterprises, held together by the unifying bond of interest in the development and application of nuclear energy for peaceful purposes. Consequently, the Association's membership includes uranium mining and refining companies, manufacturers, electric power utilities, architects and consulting engineers, construction firms, banks, insurance companies, transportation companies and non-profit enterprises such as educational institutions, research laboratories, labour unions, and departments of federal and provincial governments.

In addition, the Association caters to the requirements of individuals interested in nuclear energy by fulfilling the functions of a learned society through the Canadian Nuclear Society (CNS). This Society, which is the Technical Society of the Canadian Nuclear Association, provides a forum for the exchange of specialized knowledge relating to all aspects of the peaceful uses of nuclear energy.

Who's who in the CNA

CNA Board of Directors

Chairman

F.M. Foulkes,* Chairman, Canatom Incorporated

1st Vice-Chairman

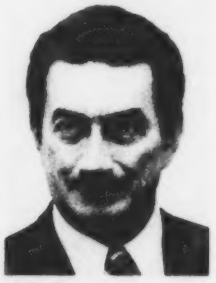
R.E. Lloyd,* President, Saskatchewan Mining Development Corporation

2nd. Vice-Chairman

R.E. Vuia* President, C-E Canada Limited

Directors

P. Amyot, Vice President, Equipment Program, Hydro Quebec



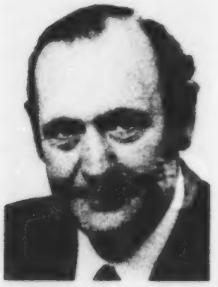
J.R. Brisson, President, Marine Industries Limited

W.H. Bulger,* Vice President & General Manager, Donlee Manufacturing Industries Limited

P.G. Campbell,* Executive Vice President Operations, Ontario Hydro

N.B. Cavadias, President, CAE Electronics Limited

H.C. Dickout, Vice President & General Manager, Power Generation, Canadian General Electric



J. Donnelly, President, Atomic Energy of Canada Limited

N.M. Ediger, President, Eldorado Nuclear Limited

J.S. Foster, Vice President (Ontario), Montreal Engineering Company

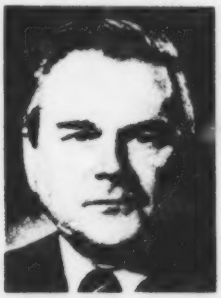
J.W. Fraser, President, Canada Forgings Division of Toromont Industries

W.L. Fraser, Vice President, TransAlta Utilities

A. Gagnon, President & CEO, Shawinigan Lavalin Incorporated

*Member, CNA Executive Committee

J.P. Gourdeau,
President & CEO,
The SNC Group



J.R. Howett,
Vice President
Industrial Sales,
Versatile Vickers
Incorporated

A.F. Lowell,
Vice President,
Minerals Marketing,
Rio Algom Limited

W. MacOwan,
Vice-Chairman,
Corporate Development
Howden Group Canada

G. Nicholson,
Vice President &
General Manager, Ceco
Consultants Limited

A.J. O'Connor,
General Manager, New
Brunswick Electrical
Power Commission

N. Olsen,
Vice President,
British Columbia
Hydro & Power
Authority

E.B. Priestner,
Vice President
Operations, Westinghouse
Canada Limited

T. Schur,
President,
Sulzer Canada
Incorporated

L.C. Secord,*
President,
DSMA ATCON Limited

H. Sonnenberg,
President,
Lummus Canada
Incorporated

J.J. Stewart,
President,
Babcock & Wilcox
Canada Limited

H.E. Tibbo,
General Manager,
London Nuclear
Limited

J.G. Warnock,
Vice President,
Acres Consulting
Services Limited

G.T. Willmon,
President,
Esso Minerals Canada

Hon. Director

J.L. Gray,
Deep River, Ontario

Ex-Officio

G.T. Leslie,*
Chairman,
CNA Council

Ex-Officio

P.A. Ross-Ross,*
President,
Canadian Nuclear Society

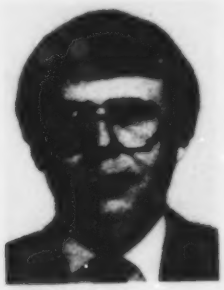
CNA Staff

N. Aspin,
President
Canadian Nuclear Association

J.A. Weller,
General Manager

CNA staff continued

J. Baisden,



D. McArthur,

S. McDonough,

D. T. Waechter

CNA Headquarters

The CNA headquarters is located at 111 Elizabeth Street, Toronto, Ontario M5G 1P7.

It contains a full-time staff of six (6) persons. The facilities include a small library which contains a comprehensive collection of reference material on a broad range of subjects relating to nuclear energy. This library is used extensively by the CNA member organizations and as a basis for CNA responses to specific information requirements of individual members. The library is also made available on a limited basis to members of the general public.

CNA Council and Standing Committees

Much of the work of the Canadian Nuclear Association is undertaken by eight Standing Committees covering the most significant areas of activity in the field of nuclear energy. The work of these committees is co-ordinated by the CNA Council comprising of an elected Chairman and Vice-Chairman as well as the Chairman and one other representative of each of the Standing Committees. The following are the existing CNA Standing Committees and abbreviations of their general terms of reference.

CNA Council
Chairman, G.T. Leaist, Saskatchewan Mining Development Corp.

To recommend policies arising from the work of the Standing Committees, to initiate studies and actions within the Standing Committees and to co-ordinate these activities.

Economic Development Committee
Chairman, P. Pickerill, Canatom Inc.

To study, maintain and disseminate information on the economic factors affecting nuclear energy, particularly in its application to Canada.

Education and Manpower Committee
Chairman, R.B. Harrison, Ontario Hydro

To study the manpower requirements created by Canada's nuclear program and to propose standards and procedures for maintaining the appropriate capability.

International Affairs Committee
Chairman, S. Dragon, Canadian General Electric Co.

To stimulate foreign trade for the nuclear industry through study of international markets for uranium, exports, radioisotopes and other products and services.

Legislative Committee
Chairman, W.M. Brown, Canadian General Electric Co.

To monitor and examine developments leading to legislation affecting nuclear energy in Canada and to propose amendments as appropriate.

Public Affairs Committee
Chairman, D.G. Somers, Saskatchewan Mining Development Corp.

To identify public affairs issues and recommend appropriate actions. To undertake media relations, co-ordinate speakers bureau, conduct studies of public attitudes, issue publications and audio-visual materials, etc.

Safety and Environment Committee
Chairman, R.M. Williamson, Atomic Energy of Canada Ltd.

To assess information on hazards to people and the environment due to nuclear energy and to assist the Association in the dissemination of this information.

Social Issues Committee
Chairman, S.G. Horton, Ontario Hydro

To identify and respond to social issues relating to the development and utilization of nuclear energy. To serve as a resource for advice concerning moral and ethical issues relating to nuclear energy.

Technology Committee
Chairman, B.C. Stonehill, DSMA ATCON Limited

To monitor developments or deficiencies in nuclear technology requiring action by the Association. To develop understanding of technological developments through technical meetings, conferences and visits.

CNA Membership Fees

CNA member organizations pay annual dues which are related to the size of each member organization and its degree of involvement in the field of nuclear energy. For the 1983 financial year the fourteen categories of CNA corporate membership dues are as follows:

$ 170.00	1,045.00	10,375.00
290.00	1,710.00	12,570.00
350.00	2,890.00	22,510.00
465.00	4,385.00	27,810.00
700.00	6,950.00	

In addition, there are Associate membership categories for certain types of organizations having a limited connection with Canada's nuclear industry such as foreign companies and agencies, also a subsidized level of membership for educational establishments.

Heroes of Canada's Nuclear Industry

Each year the Canadian Nuclear Association presents awards to persons who have made a unique contribution to the development of nuclear energy in Canada. The W.B. Lewis medal has been awarded since 1974 to scientists and engineers who have demonstrated technical accomplishments in nuclear science and engineering as exemplified by Dr. W.B. Lewis, former Senior Vice-President (Science), Atomic Energy of Canada Ltd. The Ian McRae award has been presented since 1977 to honour persons who have made outstanding contributions (other than scientific) to nuclear energy in Canada as exemplified by the late Ian F. McRae, first president of the Canadian Nuclear Association and former Chairman of the Board of Directors of the Canadian General Electric Co. Ltd.

The following are the winners of the two CNA awards since their inception, together with abbreviated citations.

W.B. Lewis Medal

1974 Harold A. Smith, Chief Engineer, Ontario Hydro
"Led a small group of scientists and engineers to translate the heavy water nuclear reactor concept into a technically feasible and economically viable system. He personally engaged in much of the basic and detailed analysis."

1975 George C. Laurence, President, Atomic Energy Control Board
"The development and establishment of an effective and viable system of reactor safety criteria and assessment including pioneering development of probability methods for nuclear reactors."

1976 John W. Hilborn, Head, Quality Control Branch, Atomic Energy of Canada Ltd.
"Pioneered Slowpoke, the low power, low cost nuclear reactor valuable in research and for medical and industrial applications. Also, simplified in-core neutron flux and spectrum monitors in worldwide use."

1977 Arthur G. Ward, Director, Applied Physics Division, Atomic Energy of Canada Ltd.
"A key role in establishing the foundation of reactor physics on which the successful development of the CANDU concept is based. Responsible for supervising the bulk of Canadian research and development effort in reactor physics during the critical period 1952-1967."

1978 William G. Morison, Director, Design & Development Division, Ontario Hydro
"Outstanding technical contributions to the design and development of the CANDU system, especially for his innovative work on the Bruce Generating Station and design decisions which contributed to the performance of the Pickering Generating Station."

1979 John S. Foster, Vice-President (Ontario), Montreal Engineering Co. Ltd.
"For a major and effective contribution to the overall management of nuclear projects in Canada and abroad in which he became personally and extensively involved in the detailed evolution of underlying design principles and the selection of difficult design alternatives. Also, for distinguished service to international bodies such as the World Energy Conference and the International Atomic Energy Agency."

1980 Ara J. Mooradian, Executive Vice-President, Research & Development, Atomic Energy of Canada Ltd.
"Responsible for taking the short fuel element concept from the laboratory to commercial mass production leading to reliable low cost fuel as a significant factor in the successful operation of CANDU reactors."

1981 Robert G. Hart, Executive Vice-President, Research Company, Atomic Energy of Canada Ltd.
"For giving the Whiteshell Nuclear Research Establishment world recognition in such fields as organic heat transport technology, thermalhydraulic technology for nuclear safety technology analysis, radioactive waste management."

1982 Ernest Siddall, Atomic Energy of Canada Ltd.
"For fundamental contributions to moderator level and liquid zone control, control room design, redundancy and coincident techniques. His innovative approach to safety and risk analysis made a major impact on all nuclear power plant design."

Ian McRae Award

1977 Lorne McConnell, General Manager — Operations Ontario Hydro
"For a critical role in developing Canada's capacity to make reactors operate successfully through careful staff selection, thorough training and good operational structure and procedures leading to reliability and safety of CANDU power reactors."

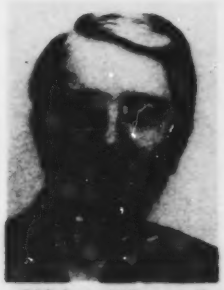
1978 William M. Brown, Manager, Turbine & Generator, Marketing & Engineering, Canadian General Electric Co. Ltd.
"For leadership in the development of the world's first practical on-power fuelling machine for power reactor leading to high operating availability."

1979 Yvon DeGuise, Chairman, Nucleotec Inc.
"Responsible for launching the province of Quebec into the nuclear field during his time as Director General of Production & Transport of Hydro Quebec and subsequently as a Commissioner of Hydro Quebec."

1980 O. John C. Runnalls, Professor of Energy Studies, University of Toronto
"The main architect of a federal government uranium policy which assesses priority supplies of uranium of Canadian utilities and secures optimum returns for Canada on uranium exports."

1981 George A. Pon, Corporate Vice-President Engineering, Atomic Energy of Canada Ltd.
"One of the few nuclear experts in Canada who have the technical expertise, excellent organizing ability and leadership, and communication which have made him one of the most vital contributors to marketing of CANDU reactors."

1982 Roy F. Errington, Head, Radiochemical Company, Atomic Energy of Canada, Ltd.
"The founding, directing, managing and nurturing of radioisotopes sales to a world marketplace in which Canada became a major supplier." ■



1982 Award Winners: Ernest Siddall, W.B. Lewis Medal; Roy F. Errington, Ian McRae Award.

Canadian Nuclear Society

The Canadian Nuclear Society is an individual-membership learned society which operates as the technical society of the Canadian Nuclear Association but with a wide degree of autonomy. One of the prime objectives of the society is the development of opportunities for the exchange of information relating to nuclear science and technology among diverse specialists both within the society and with other established learned societies. The 1983 fee for membership in the Canadian Nuclear Society is $30.00 per year. The address of the Society is:

Canadian Nuclear Society
111 Elizabeth St.
Toronto, Ontario
M5G 1P7

Canadian Nuclear Society Council

President	P.A. Ross-Ross
Immediate Past-President	G.R. Howey
Vice-President, Communications	Dr. J. Hewitt
Secretary-Treasurer	P. Stevens-Guille
	Dr. G. Bereznai
	E.C. Card
	J. Charuk
	Dr. T. Colenbrander
	Dr. T.S. Drolet
	J. Howieson
	Dr. I. Itzkovitch
	J.A. Weller

The activities of the Canadian Nuclear Society are largely conducted within individual branches as follows:

Chalk River	Dr. T.J. Hastings Fuel Materials Branch Building 375 Atomic Energy of Canada Ltd. Chalk River Nuclear Laboratories Chalk River, Ontario K0J 1J0
Manitoba	Mr. E.C. Card W.P. Wardrop & Associates 77 Main St. Winnipeg, Manitoba R3C 3H1
Ottawa	Dr. F.N. McDonnell Executive Assistant to the President Atomic Energy of Canada Ltd. 275 Slater St. Ottawa, Ontario K1A 0S4
Quebec	Mr. J.-G. Charuk Quebec Operations Atomic Energy of Canada Ltd. 1600 Dorchester Blvd. West Montreal, Quebec H3H 1P9
Toronto	Mr. A. Guthrie CANDU Operating Station Support Services Atomic Energy of Canada Ltd. Sheridan Park Research Community Mississauga, Ontario L5K 1B2

In addition the technical interests of CNS members are grouped within four Technical Divisions as follows:

Nuclear Science and Engineering	Dr. R. Bonalumi Nuclear Studies & Safety Ontario Hydro 700 University Ave. Toronto, Ontario M5G 1X6
Design and Materials	Mr. R. Doucet Canatom Inc. C.P. 409, Tour de la Bourse Montreal, Quebec H4Z 1K3
Mining, Manufacturing and Operations	Mr. J. Howieson Advisor, Nuclear Waste Management Dept. of Energy, Mines & Resources 580 Booth St. Ottawa, Ontario K1A 0E4
Environmental Health, Waste Management and Public Affairs	Dr. T. Drolet Fusion Eng. Materials Program Ontario Hydro 620 University Ave. U11 Toronto, Ontario M5G 1X6

Calendar of Events

**Source for non-CNA conferences: Meetings on Atomic Energy, International Atomic Energy Agency, Vienna, Vol. 15, No. 1, January 1983*

1983

JUNE 12-15

23rd Annual International Conference of the Canadian Nuclear Association and 4th Annual Conference of the Canadian Nuclear Society. Queen Elizabeth Hotel, Montreal, Quebec, Canada. Contact the CNA office.

JULY 11-14

7th International Symposium on Nuclear Quadrupole Resonance, Kingston, Ontario, Canada. Contact: R.J.C. Brown, Chemistry Dept., Queen's University, Kingston, Ontario, Canada K7L 3N6

JULY 24-28

6th International Symposium on Plasma Chemistry, Montreal, Quebec, Canada. Sponsored by the International Union of Pure and Applied Chemistry. Contact: Prof. Maher Boulos, Département de génie chimique, Faculté des sciences appliquées, Université de Sherbrooke, Sherbrooke, Québec, Canada, J1K 2R1

AUG 29 - SEPT 9

United Nations Conference for the Promotion of International Co-operation in the Peaceful Uses of Nuclear Energy for Economic and Social Development, Sponsored by the United Nations. Contact: Secretary-General, UN Conference for the Promotion of International Co-operation in the Peaceful Uses of Nuclear Energy for Economic and Social Development, United Nations, New York, NY 10017, USA

SEPT 6-9

International Conference on Numerical Methods in Nuclear Engineering, Montreal, Quebec, Canada. Co-sponsored by the CNS and ANS. Contact: R.A. Bonalumi, Ontario Hydro, 700 University Ave., Toronto, Ontario, Canada, M5G 1X6.

SEPT 11-15

4th Pacific Basin Nuclear Conference, Vancouver, B.C., Canada. Hosted by the CNA and co-sponsored by the CNS, ANS and participating Pacific Basin nuclear societies and forums. Contact the CNA office.

SEPT 18-23

12th World Energy Conference, New Delhi, India. Sponsored by the International Executive Committee, World Energy Conference. Contact: E. Ruttley, Secretary-General, World Energy Conference, 34 St. James, St., London SW1A 1HD, United Kingdom.

(continued on page 61)

Attention Nucleophiles!

Canadian Nuclear Society

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- [illegible] CNS [illegible]
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Canadian Nuclear Society
Société Nucléaire Canadienne

MEMBERSHIP APPLICATION

A. PERSONAL DATA

Surname: _____ Given Names: _____
(underline name used)

Indicate desired mailing address in one of the check boxes:

☐ Home Address _____
(street) (city) (province) (country) (postal code) (phone number)

☐ Business Address _____
(street) (city) (province) (country) (postal code) (phone number)

B. MEMBERSHIP DATA

Employer _____ Business Title (if applicable) _____

Membership in technical or scientific societies, institutes or professional associations: _____

EDUCATION	Institution	Discipline	Degree/Diploma	Date

Please indicate one or two CNS Technical Divisions most accurately reflecting your interests:

A ☐ Nuclear Science B ☐ Design & Materials C ☐ Mining, Manufacturing & Operations D ☐ Environment, Health & Public Affairs

Are you interested in attending local Branch events? ☐ Yes ☐ No

Are you willing to serve as an executive on the following Canadian Nuclear Society Committees?

☐ Administration ☐ Technical Division ☐ Branch

Previous experience on committees: _____

Language of correspondence: ☐ French ☐ English

C. FEES

Member: $30.00 - January 1 to December 31, 1983
$15.00 - July 1 to December 31, 1983
Student: $ 5.00 - January 1 to December 31, 1983

Mail to: Canadian Nuclear Society
111 Elizabeth St., 11th Floor
Toronto, Ont., Canada M5G 1P7

Date: _____ Signature: _____

Publications available from the CNA

The following publications are available from the CNA. They are published by the CNA, the Canadian Nuclear Society (CNS), Atomic Energy of Canada Ltd. (AECL), Ontario Hydro or by other organizations involved with nuclear power in Canada. This list is revised annually and replaces all previous CNA publications lists.

Address of Canadian Nuclear Association/Canadian Nuclear Society:
111 Elizabeth St., 11th Floor; Toronto, Ontario, Canada; M5G 1P7.

Economic Impact

The Nuclear Industry's Impact on Canada's Economy: 3 pages, 21 × 28 cm. An article by Norman Aspin, CNA President, highlighting the findings of the CNA report "Economic Benefits Arising from the Canadian Nuclear Industry." Individual copies available on request. No charge.

The National Energy Board — Intervention of the Canadian Nuclear Association: 7 pages, 21 × 28 cm. A presentation to the National Energy Board of November 1982, illustrating the benefits to Canada from the nuclear industry and supporting increased electricity exports to the US from New Brunswick's Point Lepreau nuclear power station. Individual copies available on request. No charge.

Economic Benefits Arising from the Canadian Nuclear Industry: 21 × 28 cm. English only. ISBN 0-919307-23-X. 95 pages, dated March 1982. CNA report using growth scenarios to predict the future size and economic benefits of Canada's nuclear industry. CNA members: $12.50 per copy, non-members: $25.00.

Economic Impact of Nuclear Energy Industry in Canada: 21 × 28 cm. The study by Leonard & Partners Ltd., released September 1978, commissioned by the CNA Economic Development Committee. An analysis of the Canadian nuclear industry's structure, importance to the economy and future in view of the confirmed and provisional nuclear power program. Executive Summary: French, ISBN 0-919307-08-6, or English, ISBN 0-919307-07-8. 31 pages. $2.50 for CNA members, $10.00 for non-members. Detail Report, English only. ISBN 0-919307-09-4. 250 pages. $10.00 for CNA members, $50.00 for non-members.

Nuclear Power — General

Nuclear Canada: 8 pages, 21 × 28 cm. Partly bilingual. ISSN 0029-5469. The official monthly magazine of the Canadian Nuclear Association. Contains general news and information on nuclear developments in Canada, upcoming conferences etc. Back issues only are available to non-members. One year volume of back issues $8.00 to members, $15.00 to non-members.

Nuclear Canada Yearbook 1983: 21 × 28 cm. English only. ISSN 0383-8536. Buyers' and sellers' guide to the Canadian nuclear industry with articles on the Canadian and world power programs, and the CNA. CNA/CNS members: $8.00 per copy, non-members: $10.00 per copy. Bulk rates and back issues available.

CNS Bulletin: 8 pages, 21 × 28 cm. ISSN 0714-7074. Bimonthly newsletter of the Canadian Nuclear Society, available through membership with the CNS.

Nuclear Power in Canada — Questions and Answers: 21 × 28 cm, 68 pages. 2nd edition, 1981. Softcover: ISBN 0-919307-17-5, $4.50 per copy. Hardcover: ISBN 0-919307-19-1, $7.50 per copy. Bulk rates available. Contains answers to some of the most commonly asked questions about nuclear power and its use in Canada.

L'énergie nucléaire au Canada: Questions et réponses: 21 × 28 cm, 73 pages. 2e édition, 1982. Reliure souple seulement. ISBN 0-919307-22-1. Livret de l'ANC offrant des réponses à certaines des questions les plus fréquentes au sujet de l'énergie nucléaire et de son utilisation au Canada. 4.50$ l'exemplaire. Tarif réduit pour grosses commandes.

Nuclear Energy in Canada: The CANDU System: 9 pages, 21 × 28 cm. English or French. AECL booklet, outlines the basics of fission, CANDU safety, costs and fuel cycles. Individual copies available on request. No charge.

Nuclear Industry Review: Problems and Prospects 1981-2000: 66 pages, 21 × 28 cm. French or English. The 1982 Canadian Government review document by Energy, Mines and Resources Canada examining the nuclear industry outlook and viability. Individual copies available on request. No charge.

Nuclear Policy Review: Background Papers: 358 pages, 21 × 28 cm. French or English. A collection of 16 papers written by several Canadian Government departments by Energy, Mines and Resources Canada, on many aspects of the Canadian nuclear power program. Individual copies available on request. No charge.

World List of Nuclear Power Plants: 16 pages, 21 × 28 cm. English only. The latest list of commercial nuclear power plants in operation or under construction, reprinted from *Nuclear News*. Individual copies available on request. No charge.

World Power Reactor Performance: 4 pages, 21 × 28 cm. English only. Ontario Hydro brochure ranking the best nuclear reactors, including several CANDU. Individual copies available on request. No charge.

What is Nuclear Energy?: CNA pamphlet, 9 × 21 cm, bilingual. Kinetic energy, definition of atom, fission and fusion, isotopes and chain reaction. Individual copies available on request. No charge.

Why Use Nuclear Energy?: CNA pamphlet, 9 × 21 cm, bilingual. Growth in demand, conservation, conventional and alternate energy and CANDU. Individual copies available on request. No charge.

The Nuclear Story: 2 pages, 21 × 28 cm. English only. Ontario Hydro brochure outlining the nuclear fission process. Individual copies available on request. No charge.

What is Meant by Fuel Cycle?: CNA pamphlet, 9 × 21 cm, bilingual. Definition, benefits of once-through natural uranium cycle, reprocessing, plutonium recycle and thorium cycle. Individual copies available on request. No charge.

Prospects for Future CANDU Fuel Cycles: 6 pages, 21 × 28 cm. English only. AECL booklet, describes the versatility of the CANDU in the future use of thorium and plutonium fuel cycles. Individual copies available on request. No charge.

What is CANDU?: CNA pamphlet, 9 × 21 cm,

bilingual. Description, heavy water, efficiency. Individual copies available on request. No charge.

CANDU 600: 18 pages, 21 × 28 cm. English or French. AECL booklet, an introduction to the AECL standard 600 MWe reactor used at Gentilly, Point Lepreau and for export. Outlines the CANDU design and system. Individual copies available on request. No charge.

Technical Summary — CANDU Nuclear Generating Station: 54 pages, 21 × 28 cm. An AECL booklet illustrating the CANDU 600MW station design features. Individual copies available on request. No charge.

Pickering Generating Station: 4 pages, 21 × 28 cm. English only. Ontario Hydro brochure describing the station and its operations, with photos. Individual copies available on request. No charge.

Pickering Generating Station Data Units 1-4: 2 pages, 21 × 28 cm. English only. Ontario Hydro brochure with technical design and operating data for buildings and reactors. Individual copies available on request. No charge.

Bruce Nuclear Power Development: 4 pages, 21 × 28 cm. English only. Ontario Hydro brochure with summary of Bruce Nuclear Power Development, heavy water plant, reactors and waste storage area. Individual copies available on request. No charge.

Bruce Generating Station Data Units 1-4: 2 pages, 21 × 28 cm. English only. Ontario Hydro brochure with technical design and operating data for buildings and reactors. Individual copies available on request. No charge.

Darlington Generating Station: 4 pages, 21 × 28 cm. English only. Ontario Hydro brochure with description of the Darlington construction site and proposed structures. Individual copies available on request. No charge.

Uranium and Nuclear Issues: 156 pages, 21 × 28 cm. English only. ISBN 0-919307-28-0. Proceedings of a CNA seminar held November 1982, with 8 papers dealing with uranium, risk, radiation standards and government policies. $15.00 to CNA members, $25.00 to non-members.

CNA 22nd Annual International Conference Summaries (1982): 21 × 28 cm. French, ISSN 0706-1900, or English, ISSN 0706-1293. (Previous name: CNA Annual International Conference Proceedings)

Volume 1

Chairman's Address, President's Address and CNA Committee Reports, with reports of CNA and CNS Councils. 36 pages, bilingual.

Volume 2

Conference Summaries on "Present Status of Nuclear Projects and Future Nuclear Power Plans," "Export of Electricity and Technology," "Canada's Uranium Industry," and "Nuclear Opportunities." 19 summaries, 14 pages, French or English volumes.

CNA/CNS Members: $10.00, non-members: $15.00. (If CNS 1982 Annual Conference Summaries included: $15.00 to CNA/CNS Members, $25.00 to non-members)

Some complete papers are available: CNA/CNS Members: $2.50 per paper, non-members: $3.50 per paper.

Individual volumes not available.

CNS 3rd Annual Conference Summaries (1982): 21 × 28 cm. French, ISSN 0227-0137, or English, ISSN 0227-0129, c. 200 pages. Contains 42 summaries of technical papers on CANDU physics and related topics. CNA/CNS members: $10.00, non-members: $15.00. (Previous name: CNS Transactions). Make cheque payable to Canadian Nuclear Society.

CNS 3rd Annual Conference Proceedings (1982): 21 × 28 cm. English only, ISSN 0227-1907, c. 400 pages. Contains complete technical papers and plenary session papers. CNA/CNS Members: $30.00, $40.00 to non-members. Previous volumes available since 1980. Make cheque payable to Canadian Nuclear Society.

The Nuclear Debate

The Case for Nuclear Power/The Case Against Nuclear Power: 3 pages, 21 × 28 cm. English only. An article from the November 1980 issue of *Current* on the various arguments of the nuclear power debate. Individual copies available on request. No charge.

Nuclear Energy — Pro and Con: 10 pages, 21 × 28 cm. English only. Arguments concerning the Canadian nuclear debate, with Les Shemilt (pro) and Gordon Edwards (con). Published in "Signs of the Times: Resources for Social Faith" (United Church of Canada, 1981). Individual copies available on request. No charge.

Risks and Benefits of Atomic Energy: 2 pages, 21 × 28 cm. English only. Vatican statement to the International Atomic Energy Agency, on the value of peaceful nuclear energy, and the need for disarmament. Published in *Origins*, October 7, 1982. Individual copies available on request. No charge.

The Nuclear Energy Debate: Scientists, The Media and the Public: 6 pages, 21 × 28 cm. A report on the overwhelming support which scientists give to nuclear power, unlike the public. Published in *Public Opinion*, August/September 1982. Individual copies available on request. No charge.

The Health Hazards of Not Going Nuclear: 8 pages, 21 × 28 cm. English only. An article by Leo Yaffe, published in the December 1979 issue of *Chemistry in Canada*, comparing the health risks of nuclear with coal electricity generation. Individual copies available on request. No charge.

Nuclear Responsibility: 9 × 20 cm. English or French. AECL brochure, contains 15 questions and answers on nuclear issues in Canada. Individual copies available on request. No charge.

Bibliography — Nuclear Power Morals and Ethics: 8 pages, 21 × 28 cm. English only. A CNA bibliography listing 100 references to ethics and nuclear energy use. Individual copies available on request. No charge.

Moral and Ethical Issues Relating to Nuclear Energy Generation: 212 pages, 21 × 28 cm. English only. ISBN 0-919307-15-9. Proceedings of a CNA seminar held March 1980 with 8 papers and 4 workshop reports dealing with ethical considerations in the Canadian nuclear fuel cycle. $7.50 per copy.

The Nuclear Challenge: Understanding the DeLute: 224 pages, 15 × 23 cm. A non-technical, pro-nuclear book by Alan Wyatt on the nuclear controversy in Canada, published in 1978 by Book Press Ltd. Available for $2.00 softcover, $4.00 hardcover, from the CNA.

Seminar for Industry Spokesmen: 268 pages, 21 × 28 cm. English only. ISBN 0-919307-04-3. Proceedings of a CNA seminar, with 14 papers dealing with important facets of nuclear power, presented to get the material across to a non-technical audience. November 1976. $15.00 per copy.

Nuclear Power and the Canadian Public: 400 pages, 21 × 28 cm. English only. ISBN 0-919307-02-7. June, 1976 report by the York University Institute for Behavioural Research. Contains complete text of research report into public attitudes towards nuclear power, commissioned by the CNA. Includes survey of major statistical results, and detailed methodology of questionnaire. Members: $20.00 per copy, non-members: $25.00 per copy.

Safety

Hydro and the Environment: 32 pages, 14 × 21 cm. English only. Ontario Hydro booklet describing Hydro's impact on the environment and measures taken to protect the environment. Discusses hydro-electric, coal-fired and nuclear generating stations as well as transmission facilities, with photos and illustrations. Individual copies available on request. No charge.

What is Radiation?: CNA pamphlet, 9 × 21 cm, bilingual. Definition, properties, origin and use in nuclear power plants. Individual copies available on request. No charge.

What is Radioactivity?: CNA pamphlet, 9 × 21 cm, bilingual. Definition and properties of the atom, isotopes, radioactivity, half-life and commercial uses. Individual copies available on request. No charge.

Living with Radiation: 9 × 21 cm. English or French. AECL brochure: a brief description of radiation, the various types of radiation, some uses of ionizing radiations and the risks involved. Individual copies available on request. No charge.

How Dangerous is Radiation? 6 pages, 21 × 28 cm. English only. An article by Bernard Cohen on the risks of radiation in relation to other common risks, published in *Ascent*, Vol. 2, No. 4, 1981. Individual copies available on request. No charge.

What Are the Biological Effects of Radiation?: CNA pamphlet, 9 × 21 cm, bilingual. Radiation particles, assessment of extent of damage and hereditary effects. Individual copies available on request. No charge.

Safety of CANDU Nuclear Power Stations: 15 pages, 21 × 28 cm. English or French. AECL booklet, covers the nature on risks, the evolution of Canadian safety philosophy and CANDU safety features. Individual copies available on request. No charge.

CANDU Reactor Safety: 10 × 23 cm. English or French. AECL brochure, uses a question-answer approach describing the CANDU safety philosophy. Individual copies available on request. No charge.

CANDU Reactor Safety Design: 100 pages, 21 × 28 cm. English only. ISBN 0-919307-18-3. Proceedings of a CNA symposium held in Toronto, November 1978. Contains eleven papers on control of public risk, safety during normal and abnormal reactor operations and predicting accident consequences. Members: $10.00 per copy, non-members: $15.00 per copy.

Nuclear Power Risks in Perspective: 21 × 28 cm. English only. ISBN 0-919307-21-3. Proceedings of a seminar sponsored by the CNA Safety and Environment Committee, May 1981, with 10 papers on the topics of risk assessment in the nuclear fuel cycle and the public's perceptions of risks. $10.00 per copy.

Safety Policy in the Production of Electricity: 13 pages, 21 × 28 cm. English only. A 1982 paper by E. Siddall of AECL on the direct relationship between safety and electricity use. Individual copies available on request. No charge.

A Reactor Cannot Explode Like a Nuclear Bomb: 16 pages, 21 × cm. English only. Paper by D.A. Meneley of Ontario Hydro on the reasons CANDU can not result in a nuclear explosion. Individual copies available on request. No charge.

Preventing Nuclear Weapons Proliferation: A Positive Factor for Peace: 11 pages, 21 × 28 cm. English only. An article by J.A.L. Robertson of AECL emphasizing that nuclear power stations reduce the likelihood of nuclear proliferation. Published in *Energy Newsletter*, October 1982. Individual copies available on request. No charge.

Decontamination of Nuclear Facilities: 21 × 28 cm. English only. ISBN 0-919307-25-6. 3 volumes containing 42 papers presented at an international conference held September 19-22, 1982 in Niagara Falls, co-sponsored by the Canadian Nuclear Association and the American Nuclear Society. $100.00 per set.

Decommissioning of CANDU Nuclear Power Stations: 6 pages, 21 × 28 cm. English or French. AECL booklet, describes procedures and costs of dismantling a nuclear power station. Individual copies available on request. No charge.

The Human Dimension in Energy Technology: 21 × 28 cm. English only. ISBN 0-919307-26-4. c. 200 pages. Proceedings of the Joint Conference on Human Factors in Control Room Design and Operation, held June 23, 1982 in Toronto, sponsored by the Canadian Nuclear Association and the Human Factors Association of Canada. CNA members: $10.00, non-members: $15.00.

How Are Nuclear Power Plants Licensed and Regulated? CNA pamphlet, 9 × 21 cm, bilingual. Role of AECB, site approval, construction license, operating license. Individual copies available on request. No charge.

What Are the Thermal Effects of Nuclear Power Plants?: CNA pamphlet, 9 × 21 cm, bilingual. Efficiency, local environmental effects and proposed uses of waste heat. Individual copies available on request. No charge.

Uranium

What is Uranium?: CNA pamphlet, 9 × 21 cm, bilingual. Abundance, processing to fuel pellets, isotopes and use in CANDU reactors. Individual copies available on request. No charge.

Uranium: The Energy Mineral: 20 pages, 21 × 28 cm. English only. A booklet produced by Denison Mines Ltd. on its history, uranium ore types and mining and milling processes. Individual copies available on request. No charge.

Uranium and Electricity: 52 pages, 15 × 23 cm. English only. Booklet produced by Eldorado Resources Ltd. illustrating uranium's contribution to world energy, the entire nuclear fuel cycle, radiation, nuclear medicine and export policy. Individual copies available on request. No charge.

Refining and Converting Uranium into Nuclear Fuels: 10 pages, 21 × 28 cm. English only. Booklet produced by Eldorado Resources Ltd. describing in detail the chemical sequence in refining uranium and converting it into nuclear reactor fuel material. Individual copies available on request. No charge.

Uranium in Canada: 1980 Assessment of Supply and Requirements: 36 pages, 16 × 24 cm. Bilingual. Report EP 81-3 by Energy, Mines and Resources Uranium Resource Appraisal Group (URAG). Canada's known and speculative uranium resources, domestic uranium needs and exploration programs are outlined. Individual copies available on request. No charge.

CNA Submission to the Uranium Inquiry, Nova Scotia: c. 80 pages, 21 × 28 cm. ISBN 0-919307-27-2. A 3-part Canadian Nuclear Association presentation to the McCleave commission, October 1982, supporting uranium mining in Nova Scotia and dealing with radiation risk and waste management. $5.00 per copy.

Waste Management

What is Done With Irradiated Nuclear Fuel?: CNA pamphlet, 9 × 21 cm, bilingual. Description, fuel bundle, underwater and underground storage and nuclear waste decay. Individual copies available on request. No charge.

Assessing the Concept: 9 × 21 cm. English or French. AECL brochure, describes the Canadian research program into the disposing of nuclear fuel wastes deep underground in crystalline rock formations. Individual copies available on request. No charge.

Nuclear Fuel Wastes: 9 × 21 cm. English or French. AECL brochure. When uranium is used in a nuclear electric station small quantities of new radioactive materials are produced in the fuel. This pamphlet describes these wastes, their storage and the disposal options being researched. Individual copies available on request. No charge.

Management of Radioactive Fuel Wastes: The Canadian Disposal Program: 118 pages, 12 × 20 cm. English only, a reprint of report AECL-6314, edited by J. Boulton, 1978, describing the Canadian research and development program for safe, permanent disposal of radioactive wastes underground. Individual copies available on request. No charge.

Annual Report of the Canadian Nuclear Fuel Waste Management Program: 21 × 28 cm. English or French. The AECL report describing progress to date in the Canadian nuclear waste disposal program. Individual copies available on request. No charge.

Storage of Used Nuclear Fuel: 4 pages, 21 × 28 cm. English only. Ontario Hydro brochure with general description of storage of used nuclear fuel in spent fuel bays at Hydro's nuclear generating stations, with photos and illustrations. Individual copies available on request. No charge.

Transporting Irradiated Nuclear Fuel: 2 pages, 21 × 28 cm. English only. Ontario Hydro brochure describing flasks for shipping used nuclear fuel. Individual copies available on request. No charge.

Underground Research Laboratory: 9 × 21 cm. English only. AECL brochure. An Underground Research (URL) is being constructed in the Lac du Bonnet Batholith, near the Whiteshell Nuclear Research Establishment in Pinawa, Manitoba. This brochure describes how scientists will obtain information that will be valuable in assessing the disposal of fuel wastes in similar rocks in other parts of Canada. Individual copies available on request. No charge.

Measuring Earthquake Activity: 9 × 21 cm. English or French. AECL brochure. With information about the probability and severity of earthquakes, required by scientists to assess the possible effects of earthquakes in the igneous crystalline rock formations in the Canadian Shield. Individual copies available on request. No charge.

The Management of Radioactive Wastes in Canada: 199 pages, 21 × 28 cm. English only. ISBN 0-919307-11-6. Proceedings of a CNA symposium held in Toronto, April 1979. Contains ten papers on uranium mining wastes, nuclear fuel waste and federal regulation. Members $20.00 per copy, non-members $30.00 per copy.

CNS International Conference on Radioactive Waste Management Conference Summaries: 21 × 28 cm. English only. ISBN 0-919784-00-3. 325 pages. Contains summaries of papers presented at the conference held September 12-15, 1982 in Winnipeg. CNS members $15.00, non-members $20.00. Make cheque payable to Canadian Nuclear Society.

CNS International Conference on Radioactive Waste Management Conference Proceedings: 21 × 28 cm. English only. ISBN 0-919784-01-1. 673 pages. Contains complete text of over 100 technical papers under 13 subject headings on international nuclear waste research, presented September 1982. $50.00 per volume. Make cheque payable to Canadian Nuclear Society.

Miscellaneous

What you should know about the Canadian Nuclear Association: Folder, French or English. Describes the activities, services and conditions of membership in the CNA. Individual copies available on request. No charge.

Canadian Nuclear Society Membership Information: Folder, French or English. Describes the activities, services and conditions of membership in the CNS. Individual copies available on request. No charge.

This is AECL: 9 × 20 cm. brochure in French or English. AECL brochure describes the activities of AECL and contains a map giving the locations of projects. Individual copies available on request. No charge.

The Gifts of Nature: 49 pages, 14 × 21 cm. English only. Ontario Hydro booklet describing its history, fundamentals of electricity and the hydro system. Individual copies available on request. No charge.

Nuclear Energy in Québec: 32 pages, 16 × 24 cm. French only. A Hydro-Quebec brochure describing nuclear fission, the operation of the CANDU reactor and the Gentilly nuclear complex and regulations dealing with safety and radiation protection. Individual copies available on request. No charge.

Energy Update: 49 pages, 14 × 22 cm. English or French. Report E181-4E, by Energy, Mines and Resources Canada, with facts on Canada's various energy sources. Individual copies available on request. No charge.

Energy and the Value Society: 18 pages, 14 × 21 cm. English only. AECL booklet, discusses how high technology contributes to society's values. Individual copies available on request. No charge.

Electricity from the Power Station to the Home: 48 pages, 16 × 24 cm. French or English. A Hydro-Quebec brochure describing the basic types of electrical power sources, generators and transmission systems. Individual copies available on request. No charge.

Heavy Water: 4 pages. 21 × 28 cm. English or French. AECL leaflet describes the production of heavy water and its use in Canada's nuclear reactors. Individual copies available on request. No charge.

What is Heavy Water?: CNA pamphlet. 9 × 21 cm. bilingual. Properties, production and use in CANDU reactors. Individual copies available on request. No charge.

The Bruce Energy Centre: 21 × 28 cm. English only. An Ontario Energy Corporation folder on the evolving Bruce Energy Centre, to utilize nuclear steam for industry. Individual copies available on request. No charge.

Turning on Supply . . . Alternative Fuels for Transportation: 21 × 28 cm. brochure. English only. Describes the involvement of the Ontario Energy Corporation in an interlinked fuel production complex, including hydrogen, from the Bruce Nuclear Power Development. Individual copies available on request. No charge.

What is Plutonium?: CNA pamphlet. 9 × 21 cm. bilingual. Origin, properties, toxicity and proposed recycling in CANDU reactors. Individual copies available on request. No charge.

What is Thorium?: CNA pamphlet. 9 × 21 cm. bilingual. Abundance, proposed use in CANDU reactors, fuel reprocessing and radioactive fuel fabrication. Individual copies available on request. No charge.

The Modern Miner: 24 pages. 20 × 20 cm. French or English. Booklet produced by the Mining Association of Canada illustrating mining operations, safety and smelting. Individual copies available on request. No charge.

Mining: What Mining Means to Canada: 63 pages. 21 × 28 cm. French or English. Booklet produced by the Mining Association of Canada describing the steps in developing a mine, research and the future of mining. Individual copies available on request. No charge.

Mining in Canada: Facts and Figures: 18 × 25 cm. French or English. Booklet produced by the Mining Association of Canada describing the importance of mining to Canada's economy, with production statistics. Individual copies available on request. No charge.

Vocabulaire nucléaire: 90 pages. 12 × 21 cm. The English to French dictionary developed by Hydro-Québec that pertains to the nuclear industry. Translates technical terms. Individual copies available on request. No charge.

Export Insurance: 39 pages. 21 × 28 cm. English only. ISBN 0-919307-20-5. revised edition, 1981. A general guide prepared by the International Affairs Committee on the CNA for the supply of goods and services abroad, written for the company that is or may become involved in export as part of a contract to supply a nuclear facility overseas. $5.00 for members, $8.00 to non-members.

CNA Student Conference Transactions (1982): 21 × 28 cm. ISSN 0713-6323. 165 pages. Contains 15 technical papers on CANDU physics and related topics. CNA members, $20.00, non-members: $30.00.

Fusion Energy Symposium: 11 pages. 21 × 28 cm. Bilingual. ISBN 0-919307-06-X. Abstracts of the technical program of the Fusion Energy Symposium held April 11-12, 1978, Montreal. Sponsored by the CNA and the Canadian Association of Physicists. $5.00 for CNA members, $8.00 for non-members.

Education and Manpower in the Nuclear Industry: 138 pages. 21 × 28 cm. English only. ISBN 0-919307-03-5. Proceedings of a seminar organized by the CNA Education and Manpower Committee and held in Toronto, October 1976, dealing with the role of educators in the nuclear industry. Members: $15.00, non-members: $25.00.

Commercial Nuclear Fuel Technology Today: 462 pages. 21 × 28 cm. English only. ISBN 0-919307-00-0. The proceedings of the seminar organized jointly by the American Nuclear Society and the Canadian Nuclear Association in Toronto, April 29-30, 1975. Topics covered include: operating experience, fuel defect mechanisms, reprocessing and waste management, fuel fabrication, shipment of spent fuel. $10.00 per copy.

Wall charts: Pickering Generating Station B. English only. The CANDU Nuclear Power System, French or English; The Nuclear Fission Process, French or English; Sources of Radiation, French or English. CANDU 950 Power Station, English only; Sources of Radiation Exposure Compared; English only. Individual copies available on request. No charge. ■

CALENDAR OF EVENTS

(continued from page 56)

SEPT 27-30

7th International Conference on Solid State Dosimetry, Ottawa, Ontario, Canada. Contact: D. Grogan, Health & Welfare Canada, Radiation Protection Bureau, Brookfield Rd., Ottawa, Ontario, Canada K1A 1C1.

OCT 24-26

Workshop on Analytical Chemistry Related to Canada's Nuclear Industry. Hecla Island, Manitoba, Canada. Sponsored by the CNS and CNA. Contact: P. Campbell, AECL, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba, Canada R0E 1L0.

OCT 30 - NOV 4

Joint Meeting of the American Nuclear Society and the Atomic Industrial Forum, San Francisco, California, USA. Contact: D.G. Pettengill, ANS Meetings Manager, American Nuclear Society, 555 North Kensington Ave., La Grange Park, IL 60525, USA.

1984

JUNE 3-6

24th Annual International Conference of the Canadian Nuclear Association and 5th Annual Conference of the Canadian Nuclear Society, Saskatoon Centennial Centre, Saskatoon, Saskatchewan, Canada. Contact the CNA office.

JULY 15-20

5th World Hydrogen Energy Conference, Toronto, Ontario, Canada. Sponsored by the International Association for Hydrogen Energy and the National Research Council of Canada. Contact: 5th World Hydrogen Energy Conference, Conference Service, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6.

OCT 14-18

International Conference on Radiation Safety in Mining, Toronto, Ontario, Canada. Sponsored by Energy Mines & Resources Canada, Atomic Energy Control Board, and CNA. Contact the CNA office.

NOV 11-16

Joint Meeting of the American Nuclear Society and the Atomic Industrial Forum, Washington, D.C., USA. Contact: D.G. Pettengill, ANS Meetings Manager, American Nuclear Society, 555 North Kensington Ave., La Grange Park, IL 60525, USA.

1985

JUNE 2-5

25th Annual International Conference of the Canadian Nuclear Association and 6th Annual Conference of the Canadian Nuclear Society, Westin Hotel, Ottawa, Ontario, Canada. Contact the CNA office.

1986

JUNE 8-11

26th Annual International Conference of the Canadian Nuclear Association and 7th Annual Conference of the Canadian Nuclear Society, Royal York Hotel, Toronto, Ontario, Canada. Contact the CNA office.

OVERVIEW OF PUBLIC OPINION

(continued from page 50)

shortages and continued pessimism about the Canadian economy.

Decisions about building nuclear power plants, from the public perspective, are influenced by the perceived needs for nuclear power as an alternate energy source and its perceived contribution to the future development of the province. Interest continues in such factors as safety, waste disposal, cost and the environmental effects of building new nuclear powered generating stations. ■

REFERENCES

1. *CROP, June 1982. In response to the open-ended question, "Thinking of energy problems facing Canadians, what specific problems do you think are the most important? Any other problems?"*
2. *CROP Report, 83-1, February 1983. Based on a random sample of 2,017 Canadians interviewed in November 1982.*
3. *CROP Report, 83-1, February 1983.*
4. *National U.S. opinion poll, conducted by Louis Harris & Associates, for Committee for Energy Awareness, November 1982.*
5. *Gallup National Omnibus Study, September 1982.*
6. *Gallup National Omnibus Study, September 1982.*
7. *CROP, November 1982. In response to the question, "Large-scale projects designed to meet future Canadian energy demands are frequently discussed by government and business. How important do you think it is for the country to go ahead with the project? Are they very important, somewhat important, not very important or not at all important?"*

Nuclear Bibliography '83

The following is information on significant nuclear publications that have become available to the CNA library within the past year. All may be borrowed by employees of CNA member organizations, or obtained from the sources given.

Nuclear Programs

The Atomic Complex: A Worldwide Political History of Nuclear Energy: A 1982 book by Bertrand Goldschmidt on the origins of nuclear power, nuclear weapons and "current confusion". 478 pages. Available from American Nuclear Society, 555 N. Kensington, La Grange Park, IL 60525.

Economic Benefits Arising from the Canadian Nuclear Industry: A March 1982 CNA report on the size and future of Canada's nuclear program. 95 pages. Available for $12.50 to CNA members, $25.00 to non-members.

First Report from the Select Committee on Energy: The Government's Statement on the New Nuclear Power Programme: A 1981 U.K. report on nuclear reactor options and suggesting that CANDU be re-examined. 124 pages. Available as HC 114-1 from Her Majesty's Stationery Office, London, U.K. (Pendragon, in Canada).

The National Energy Program Update: 1982: A booklet released May 1982 describing changes to the NEP of 1980, including proposed financing for a Pt. Lepreau-2 nuclear reactor. French or English, 94 pages with summary. Available from Energy, Mines and Resources Canada, Communications Branch, 580 Booth St., Ottawa, Ontario, K1A 0E4.

Nuclear Energy and Its Fuel Cycle: Prospects to 2025: A 1982 report by an expert group of the OECD with the results of nuclear fuel cycle requirement calculations. 262 pages. Available from Renouf Publishing Co. Ltd., 2182 St. Catherine St. W., Montreal, Quebec, H3H 1M7.

Nuclear Energy Prospects to 2000: A 1982 report by the OECD NEA and IEA on the impact of nuclear energy, and factors affecting growth. 129 page, bilingual report available from Renouf Publishing Co. Ltd., 2182 St. Catherine St. W., Montreal, Quebec, H3H 1M7.

Nuclear Industry Almanac — Western Europe: A 1982 directory edited by Geoffrey Greenhalgh et al. with in-depth articles on European nuclear programs and suppliers. 303 pages. Published by Nuclear Energy Intelligence, available from Alan Armstrong and Associates Ltd., London Business School, Sussex Place, London NW1 4SA, England.

Nuclear Information Seminar: Proceedings of an April 1982 Seminar co-sponsored by Alberta Power Ltd. and TransAlta Utilities with papers on the increasing use of nuclear power and oil sands applications. c. 200 pages. Distributed by TransAlta Utilities Corp., 110-12th Avenue SW, Box 1900, Calgary, Alberta, T2P 2M1.

Nuclear Industry Review — Problems and Prospects 1981-2000: The federal government review, released August 4th, 1982, with the outlook for nuclear power and policy options. 66 pages. English or French. Available from the Communications Branch, Department of Energy, Mines and Resources, 580 Booth St., Ottawa, Ontario, K1A 0E4.

Nuclear Power in Developing Countries: A 1982 book by James Everett Katz et al. with information on nuclear economics, decision making, and country studies. 372 pages. Available from D.C. Heath Canada Ltd., Suite 1600, 100 Adelaide St. W., Toronto, Ontario, M5H 1S9.

Nuclear Power Station Achievement 1968-1980: A 1981 report by L.R. Howles with the operating statistics of the Western nuclear power stations and a comparison of reactor types. 40 pages. Available from Nuclear Engineering International, IPC Business Press Ltd., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS, England.

Worldwide Nuclear Plant Performance Revisited: An Analysis of 1978-81 Experience: A report, c. 1982, by Steve Thomas analysing nuclear reactor performance by country and suggesting prospects for reactor vendors. 52 pages. Available as SPRU Occasional Paper Series No. 18 from Science Policy Research Unit, University of Sussex, Mantell Building, Falmer, Brighton, Sussex BN1 9RF, U.K.

Safety

The Chemical Toxicity of Uranium with Special Reference to Effects on the Kidney and the Use of Urine for Biological Monitoring: An April 1982 report by G.J. Stopps et al. concerning airborne uranium dust. 87 pages. Available as INFO-0074 from Atomic Energy Control Board, P.O. Box 1046, Ottawa, Ontario, K1P 5S9.

Critical Flow Modelling in Nuclear Safety: A 1982 report by the OECD NEA Committee on the safety of nuclear installations. 102 pages. Available from Renouf Publishing Co. Ltd., 2182 St. Catherine St. W., Montreal, Quebec, H3H 1M7.

Decontamination of Nuclear Facilities: A 3-volume set of proceedings of an international joint topical meeting, co-sponsored by Canadian Nuclear Association and American Nuclear Society, held September 19-22, 1982. Available for $100.00 per set from the CNA.

The Dose Limitation System in the Nuclear Fuel Cycle and in Radiation Protection: Proceedings of a symposium sponsored by the International Atomic Energy Agency, held October 1981, 675 pages. Available from Unipub, 345 Park Ave. S., New York, NY 10010.

Fault Tree Handbook: A 1981 handbook by W.E. Veseley et al. with a complete methodology for reliability analysis of complex systems. c. 200 pages. Available from U.S. Nuclear Regulatory Commission, GPO Sales Program, Washington, DC 20555.

Hormesis With Ionizing Radiation: A 1980 book by T.D. Luckey reviewing research supporting the idea of radiation's benefits. 222 pages. Available from CRC Press Inc., 2000 NW 24th St., Boca Raton, Florida 33431.

The Human Dimension of Energy Technology: Proceedings of the Joint Conference on Human Factors in Control Room Design and Operation, co-sponsored by the CNA and the Human Factors Association of Canada, held June 1982. Available from the CNA for $10.00 to members, $15.00 to non-members.

A Human Factors Needs Assessment and Planning Study: A 1982 report by H.E. Price and H.P. Van Cott assessing the need for human factors research, development and regulatory action in the Atomic Energy Control Board. 94 pages. Available as INFO-0084 from Atomic Energy Control Board, P.O. Box 1046, Ottawa, Ontario, K1P 5S9.

Quality Assurance for Nuclear Power Plants: 1982 proceedings of an IAEA symposium held May 1981, including three papers on QA in Canada. 499 pages. Available from Unipub, 345 Park Ave. S., NY, NY 10010.

Risk Estimates for the Health Effects of Alpha Radiation: A 1982 report by Duncan C. Thomas and K.G. McNeill. 323 pages, available as INFO-0081 from Atomic Energy Control Board, P.O. Box 1046, Ottawa, Ontario, K1P 5S9.

Statistical Methods Applied to the Study of Respirable Dust Concentrations in Uranium Mines in Canada: A March 1982 report by C.E. Makepeace on the means to obtain best confidence limits. 154 pages. Prepared as INFO-0075 for Atomic Energy Control Board, P.O. Box 1046, Ottawa, Ontario, K1P 5S9.

The Warning — Accident at Three Mile Island: A 1982 book by Mike Gray and Ira Rosen, "a frightening but unbiased narrative of the country's closest brush with nuclear catastrophe". 287 pages. Available for $11.50 from Beaverbrooks Ltd., 195 Allstate Parkway, Valleywood Park, Markham, Ontario.

Uranium

Brinex Kitts-Michelin Uranium Project: An April 1980 report of the Kitts-Michelin Environmental Assessment Board, C.W. Powell, Chairman, concerning the Brinex Labrador uranium mining proposal. 119 pages. Available from Government of Newfoundland and Labrador, Department of Mines and Energy, P.O. Box 4750, St. John's, Newfoundland, A1C 5T7.

Canadian Mines Handbook 1982-83: A directory of Canada's mining industry. 430 pages.

Available from Northern Miner Press Ltd., 7 Labatt Ave., Toronto, Ontario, M5A 3P2.

CNA Submission to the Uranium Inquiry, Nova Scotia: The October 1982 Canadian Nuclear Association document dealing with Canada's nuclear program, the uranium industry, radiation and waste management. Available for $5.00 from the CNA.

The Great Uranium Cartel: A book by Earle Gray published in 1982 on the history of the uranium cartel and current issues. 303 pages. Available from McClelland and Stewart Ltd., 25 Hollinger Rd., Toronto, Ontario, M4B 3G2.

Impacts of Canada's Uranium Mining Industry: A 1982 report by Marvin Shaffer and Associates comparing economic impacts of uranium mining in Ontario with Saskatchewan. 87 pages. Available for $10.00 from Canadian Energy Research Institute, 3512-33 Street NW, Calgary, Alberta, T2L 2A6.

Regulatory Process for Uranium Mines in Canada: A 1982 submission, c. 200 pages to the Nova Scotia Uranium Inquiry by A. B. Dory of the Atomic Energy Control Board, P.O. Box 1046, Ottawa, Ontario, K1P 5S9.

Report of the National Technical Planning Group on Uranium Tailings Research: A 1981 report, 159 pages, by P. A. Lapp submitted to CANMET, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ontario, K1A 0G1.

Towards Safe Production: The 1981 report of the Joint Federal-Provincial Inquiry Commission into Safety in Mines and Mining Plants in Ontario. 2 volumes, available from Ontario Government Publications Centre, 880 Bay St., 5th floor, Toronto, Ontario, M7A 1N8.

Uranium: Resources Production and Demand: A 1982 report by the OECD NEA and IAEA. 213 pages. French or English. Available from Renouf Publishing Co., Ltd., 2182 St. Catherine St. W., Montreal, Quebec, H3H 1M7.

Uranium and Nuclear Energy — 1981: Proceedings of the Sixth International Symposium of the Uranium Institute, held September 1981. 400 pages. Available from Butterworth & Co. (Publishers) Ltd., Borough Green, Sevenoaks, Kent TN15 8PH, England.

Uranium Exploration Case Histories: Proceedings published in 1981 of an IAEA meeting held November 1979. 407 pages. Available from Unipub, 345 Park Ave. S., New York, NY 10010.

Uranium Exploration Methods: Proceedings of a symposium held June 1982, sponsored by the OECD Nuclear Energy Agency. 979 pages. Available from Renouf Publishing Co. Ltd., 2182 St. Catherine St. W., Montreal, Quebec, H3H 1M7.

Uranium Exploration Mining and the Nuclear Fuel Cycle: A 1982 report by the Exploration Committee, Chamber of Mineral Resources of Nova Scotia, edited by G. B. Dickie, reviewing all aspects of uranium mining, milling and regulation. 50 pages.

Waste Management

Canadian Waste Mangement Reports Index: Indexes for August 1981 (90 pages) and June 1982 (96 pages) listing AECL and AECB nuclear waste management reports, compiled by Whiteshell Nuclear Research Establishment, Pinawa, Manitoba, R0E 1L0.

CNS International Conference on Radioactive Waste Management — Conference Proceedings: Proceedings of a conference held September 1982, Winnipeg, with over 100 pages on many aspects of nuclear waste disposal. 673 pages. Available for $50.00 from the Canadian Nuclear Society, 111 Elizabeth St., 11th Floor, Toronto, Ontario, Canada, M5G 1P7. Conference summaries available for $15.00 to CNS members, $20.00 to non-members.

Disposal of Radioactive Wastes: A 1982 text by Z. Dlouhy dealing with disposal of processed nuclear waste. 264 pages. Available from Elsevier Science Publishing Co. Inc., 52 Vanderbilt Ave., New York, NY 10017.

Dry Storage of Spent Fuel Elements: Proceedings of a workshop held May, 1982 and sponsored by the OECD Nuclear Energy Agency. 272 pages. Available from Renouf Publishing Co. Ltd., 2182 St. Catherine St. W., Montreal, Quebec, H3H 1M7.

Environmental Migration of Long-lived Radionuclides: Proceedings of an IAEA symposium held July 1981, published 1982, with papers on biological uptake, transport processes and dose assessment. 831 pages. Available from Unipub, 345 Park Ave. S., New York, NY 10010.

Geological Disposal of Radioactive Waste: A May 1982 report on research into nuclear waste disposal in the OECD area. 54 pages. Available from OECD Nuclear Energy Agency, 38 boulevard Suchet, 75016 Paris, France.

Managing Low Level Radioactive Waste — Proposed Responsibilities and Management Structure — Summary: A 1981 report by Hickling Partners, recommending the creation of a federal low-level waste management office. 34 pages. Prepared for the Senior Adviser, Uranium and Nuclear Energy, EMR Canada, Ottawa, Ontario, K1A 0E4.

Third Annual Report: The June 1982 report by the Technical Advisory Committee on the Nuclear Fuel Waste Management Program evaluating all major areas of the research program. 93 pages. Available from Dr. L. W. Shemilt, c/o Room 136, Engineering Building, McMaster University, Hamilton, Ontario, L8S 4L7.

Third Annual Report of the Canadian Nuclear Fuel Waste Management Program: A report by R. S. Dixon et al. on the public interaction and R & D behind Canada's disposal program. 97 pages. Available as AECL-6821 from Scientific Document Distribution Office, AECL, Chalk River, Ontario, K0J 1J0.

Miscellaneous

CNS 3rd Annual Conference Proceedings: Proceedings of the Canadian Nuclear Society meeting held June 9, 1982. Available for $30.00 to CNA/CNS members, $40.00 to non-members, from the Canadian Nuclear Society, 111 Elizabeth St., 11th floor, Toronto, Ontario, M5G 1P7.

Energy Deskbook: A 1982 "energy encyclopedia" by Samuel Glasstone, 453 pages. Available as DE82013966 from National Technical Information Service, US Department of Commerce, Springfield, Virginia 22161.

Hydrogen: A Challenging Opportunity: A 1981 report by the Ontario Hydrogen Energy Task Force outlining hydrogen's future in Ontario's economy. 8 volumes. Available from Ontario Government Publications Centre, 880 Bay St., 5th floor, Toronto, Ontario, M7A 1N8.

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Manpower, Education
Research and Development

For more information contact:
Canadian Nuclear Association,
111 Elizabeth Street,
Toronto, Ontario, Canada M5G 1P7
Telephone (416) 977-6152 — telex 06-22741

...In the Matter of An Application... to Vary the Decision of the National Energy Board: A July 1982 document by N.B. Power concerning changes to the NEB decision on export of Pt. Lepreau electricity. c.150 pages. Created by New Brunswick Electric Power Commission, 527 King St., Fredericton, NB, E3B 4X1.

Industrial Applications of Radioisotopes and Radiation Technology: Proceedings of a conference held in 1981, sponsored by the IAEA. 594 pages. Available from Unipub, 345 Park Ave. S., New York, NY 10010.

International Tokamak Reactor: Phase One: A 1982 IAEA report of the International Tokamak Reactor Workshop, held 1980-1981, updating INTOR data and projects. 860 pages. Available from Unipub, 345 Park Ave. S., New York, NY 10010.

Introductory Physics of Nuclear Medicine: A 1982 book by Ramesh Chandra, published by Lea & Febiger, Philadelphia. 237 pages. Available from Lea & Febiger, 600 S. Washington Sq., Philadelphia, Pennsylvania, 19106-4198.

Reasons For Decision In the Matter of the Application Under the National Energy Board Act of the New Brunswick Electric Power Commission: A March 1982 report on the decision to allow nuclear electricity export to the US. 100 pages, French or English. Available from the National Energy Board, 473 Albert St., Ottawa, Ontario, K1A 0E5.

Signs of the Times: Resources for Social Faith: A 1981 book with social commentary on recent issues, including nuclear power, edited by N. Vale. 360 pages. Available from United Church of Canada, 85 St. Clair Ave. E., Toronto, Ontario, M4T 1M8.

Transactions: Proceedings of the American Nuclear Society 1982 winter meeting available as volume 43 from ANS, 555 N. Kensington Ave., La Grange Park, Illinois 60525.

Transactions: Student Conference: Proceedings of the 1982 CNA Student Conference with 15 papers on nuclear engineering. 165 pages. Available for $20.00 to CNA members, $30.00 to non-members. ■

Where Canada's Nuclear Facilities are Located

A listing by province of power reactors, uranium mine/mill facilities, heavy water plants, uranium refineries and fuel fabrication facilities, radioactive waste management facilities, research reactors, particle accelerators and number of radioisotope users.

ALBERTA

Uranium Refineries and Fuel Fabrication Facilities

Location and Licensee	Capacity (Tonnes/Year Uranium)	Status
Earth Sciences Extraction Co. Calgary	70 as U_3O_8	Operating

Radioactive Waste Management Facilities

Location and Licensee	Type	Status
University of Alberta Edmonton	Incineration of low-level combustible liquid wastes and storage of aqueous and solid wastes from the University and Edmonton area.	Operating
Dept. of National Defence Suffield	Inactive facility (no new wastes) for storage of solid wastes from military activities.	Operating

Research Reactors

Location and Licensee	Type and Capacity	Status
University of Alberta Edmonton	SLOWPOKE II 20 KW(t)	Operating

Particle Accelerators

Location and Licensee	Type	Status
Tom Baker Cancer Centre (Formerly Southern Alberta Cancer Centre) Calgary	Mevatron	Operating
" "	Mevatron	Operating
W.W. Cross Cancer Institute Edmonton	Mevatron	Operating
Dresser Industries Edmonton	Neutron Generator	Operating
Schlumberger of Canada Edmonton	Neutron Generator	Operating
University of Alberta Edmonton	Van de Graaff	Operating
University of Calgary	Neutron Generator	Operating

Radioisotopes

Number of users	352

BRITISH COLUMBIA

Particle Accelerators

Location and Licensee	Type	Status
Cancer Control Agency of British Columbia Vancouver	Mevatron	Operating
Simon Fraser University Burnaby	Neutron Generator	Operating
University of British Columbia Vancouver	TRIUMF	Operating

Radioisotopes

Number of users	329

MANITOBA

Radioactive Waste Management Facilities

Location and Licensee	Type	Status
*Whiteshell Nuclear Research Establishment (Atomic Energy of Canada Ltd.) Pinawa	WNRE Concrete Canister Facility	Operating
" "	Active Liquid Waste Treatment Centre	Operating

Research Reactors

Location and Licensee	Type and Capacity	Status
*Whiteshell Nuclear Research Establishment (Atomic Energy of Canada Ltd.) Pinawa	WR-1 Reactor (OCR) 60 MW(t)	Operating

Particle Accelerators

Location and Licensee	Type	Status
Manitoba Cancer Treatment and Research Foundation Winnipeg	Therac 40/ Sagittaire	Operating
University of Manitoba Winnipeg	Cyclotron	Operating
*Whiteshell Nuclear Research Establishment (Atomic Energy of Canada Ltd.) Pinawa	4 MeV Accelerator Facility	Operating
" "	14 MeV Neutron Generator	Operating

Radioisotopes

Number of users	112

NEW BRUNSWICK

Power Reactors

Location and Licensee	Type and Capacity	Status
Point Lepreau Generating Station Point Lepreau (New Brunswick Electric Power Commission)	CANDU-PHW 600 MW(e)	Started up 1982. Operating

Uranium Refineries and Fuel Fabrication Facilities

Location and Licensee	Capacity (Tonnes/Year Uranium)	Status
Combustion Engineering — Superheater Ltd. Moncton	250 (fuel pellets and bundles)	Operating

Radioactive Waste Management Facilities

Location and Licensee	Type	Status
Point Lepreau Radioactive Waste Management Facility (New Brunswick Electric Power Commission)	Storage of anticipated wastes from Point Lepreau Nuclear Generating Station	Operating

Particle Accelerators

Location and Licensee	Type	Status
Saint John Regional Hospital Saint John	Therac-20	Testing

Radioisotopes

Number of users 84

NEWFOUNDLAND

Uranium Mine/Mill/etc. Locations

Location and Licensee	Status
Kitts Project Nr. Postville, Labrador (Brinex Ltd.)	Underground Exploration
Michelin Project L. Kaipokok, Labrador (Brinex Ltd.)	Underground Exploration

Particle Accelerators

Location and Licensee	Type	Status
St. John's General Hospital	Linac	Operating

Radioisotopes

Number of users 40

NOVA SCOTIA

Heavy Water Plants

Location and Licensee	Capacity (Tonnes/Year)	Status
Glace Bay Heavy Water Plant (Atomic Energy of Canada Limited)	400	Operating
Port Hawkesbury Heavy Water Plant (Atomic Energy of Canada Limited)	400	Operating

Research Reactors

Location and Licensee	Type and Capacity	Status
Dalhousie University Halifax	SLOWPOKE II 20 KW (t)	Operating

Particle Accelerators

Location and Licensee	Type	Status
Dalhousie University Halifax	Neutron Generator	Operating
Victoria General Hospital Halifax	Therac 25	Operating

Radioisotopes

Number of users 110

ONTARIO

Power Reactors

Location and Licensee	Type and Capacity	Status
NPD Generating Station Rolphton (Ontario Hydro & AECL)	CANDU-PHW 25 MW(e)	Started up 1962. Operating
Douglas Point Generating Station, Tiverton (Ontario Hydro & AECL)	CANDU-PHW 200 MW(e)	Started up 1966. Operating
Pickering Generating Station "A", Pickering (Ontario Hydro)	CANDU-PHW 4 x 500 MW(e)	First unit started up 1971. Operating
Pickering Generating Station "B",	CANDU-PHW 4 x 500 MW(e)	Reactor Construction Licence in force. Unit 5 started up 1982.
Bruce Generating Station "A", Tiverton (Ontario Hydro)	CANDU-PHW 4 x 750 MW(e)	First unit started up 1976. Operating
Bruce Generating Station "B",	CANDU-PHW 4 x 750 MW(e)	Reactor Construction Licence in force.
Darlington Generating Station "A" Bowmanville (Ontario Hydro)	CANDU-PHW 4 x 850 MW(e)	Reactor Construction Licence in force

Uranium Mine/Mill/etc. Locations

Location and Licensee	Status
Agnew Lake Mine Espanola (Agnew Lake Mines Ltd.)	Decommissioning and close-out
Denison Mines Elliot Lake (Denison Mines Ltd.)	Mining Facility Operating Licensed capacity: 10,900 tonnes/day mill feed
Madawaska Mine Bancroft (Madawaska Mines Ltd.)	Mining Facility (to be decommissioned) Licensed capacity: 1,600 tonnes/day mill feed
Panel Mine Elliot Lake (Rio Algom Ltd.)	Mining Facility Operating Licensed capacity: 3,000 tonnes/day mill feed
Quirke Mine Elliot Lake (Rio Algom Ltd.)	Mining Facility Operating Licensed capacity: 6,350 tonnes/day mill feed 2,500 tonnes/y acid raffinate
Stanleigh Mine Elliot Lake (Rio Algom Ltd.)	Underground Exploration
Stanrock Mine Elliot Lake (Denison Mines Ltd.)	Underground Exploration

Heavy Water Plants

Location and Licensee	Capacity (Tonnes/Year)	Status
Bruce Heavy Water Plant Tiverton (Ontario Hydro)		
"A"	800	Operating
"B"	800	Operating
"D"	800	Facility mothballed

Uranium Refineries and Fuel Fabrication Facilities

Location and Licensee	Capacity (Tonnes/Year) Uranium	Status
Canadian General Electric Co. Ltd. Peterborough	500 (fuel bundles)	Operating
Canadian General Electric Co. Ltd. Toronto	550 (fuel pellets)	Operating
Eldorado Resources Ltd. Blind River	18,000 as UO_3	Construction
Eldorado Resources Ltd. Port Hope	5,700 as UF_6 7,700 as UO_3 1,500 as U 2,000 as UO_2	Operating
Eldorado Resources Ltd. Port Hope	9,000 as UF_6	Construction
Westinghouse Canada Inc. Port Hope	750 (fuel pellets and bundles)	Operating

*Chalk River Nuclear Laboratories (Atomic Energy of Canada Ltd.)	Recycle Fuel Fabrication Laboratories	Operating
" "	Universal Cells	"

Radioactive Waste Management Facilities

Location and Licensee	Type	Status
Radioactive Waste Storage Site 1, Bruce Nuclear Power Development, Tiverton (Ontario Hydro)	Storage of solid wastes from Bruce, Douglas Point, and Pickering nuclear generating stations	Operating
Radioactive Waste Operations Site 2, Bruce Nuclear Power Development, Tiverton (Ontario Hydro)	Incineration, compaction and storage of wastes from Bruce, Douglas Point, and Pickering nuclear generating stations	Operating. Construction Approval in effect for facility extension and central maintenance facility.
Port Granby (Eldorado Resources Ltd.)	Storage of wastes from Eldorado Resources Ltd. Refinery at Port Hope, Ontario, and chemical treatment for removal of contaminants from drainage and run-off water at the site	Operating
Welcome (Eldorado Resources Ltd.)	Inactive facility (no new wastes) for storage of wastes from previous Eldorado Resources Ltd., Port Hope operations and chemical treatment for removal of contaminants from drainage and run-off water from the site	Operating
University of Toronto	Decommissioning of Linac accelerator laboratory and storage and handling facilities at 1 Spadina Cres. and 215 Huron St. for wastes from the University and Toronto area	Operating. Construction Approval in effect.
*Chalk River Nuclear Laboratories (Atomic Energy of Canada Ltd.)	Waste Treatment Centre	Operating

Research Reactors

Location and Licensee	Type and Capacity	Status
McMaster University Hamilton	Swimming Pool 5 MW(t)	Operating
University of Toronto Toronto	SLOWPOKE II 20 KW(t)	Operating
University of Toronto Toronto	Subcritical Assembly	Operating
*Chalk River Nuclear Laboratories (Atomic Energy of Canada Ltd.)	NRU Reactor 135 MW(t)	Operating
" "	NRX Reactor 42 MW(t)	Operating
" "	PTR Reactor 100 W	Operating
" "	ZED-2 Reactor 250 W	Operating
*AECL Radiochemical Co. Tunney's Pasture	SLOWPOKE II Reactor 20 KW(t)	Operating

Particle Accelerators

Location and Licensee	Type	Status
Defence Research Establishment Ottawa	Neutron Generator	Operating
" "	Van de Graaf	Operating
McMaster University Hamilton	Tandem Van de Graaff	Operating
National Research Council Ottawa	Linac	Operating
" "	Neutron Generator	Operating
" "	Van de Graaff	Operating
Ontario Cancer Foundation Toronto	Therac	Testing
Ontario Cancer Institute Toronto	Betatron	Operating
" "	Therac 20	Operating
" "	Linac	Operating
Ontario Cancer Treatment and Research Foundation Kingston	Linac	Operating
Ontario Cancer Treatment and Research Foundation London	Betatron	Operating
Ontario Cancer Treatment and Research Foundation (Ottawa Civic Hospital) Ottawa	Linac	Operating
Queen's University Kingston	Van de Graaff	Operating
University of Guelph Guelph	Van de Graaff	Operating
University of Toronto	Neutron Generator	Operating
" "	Neutron Generator	Operating
*Chalk River Nuclear Laboratories (Atomic Energy of Canada Ltd.)	Electron Test Accelerator	Operating
" "	2.5 MV Positive Ion Van de Graaff Accelerator	"
" "	High Energy Medical Linac Facility	"
" "	MP Tandem Van de Graaff Accelerator	"
" "	Health Physics Neutron Generator	"
" "	FINS Neutron Generator	"
" "	CW Proton Linac	"
*AECL Radiochemical Co. Kanata	AECL-CP Accelerator Facility	Operating
" "	Therac 25 Cell 4	"
" "	Operation of a Therac 20	"

Radioisotopes

Number of users	1,508

Radioisotope Production Facilities

Location and Licensee	Type	Status
*Chalk River Nuclear Laboratories (Atomic Energy of Canada Ltd.)	Mo-99 Production Facility	Operating
*AECL Radiochemical Co. Kanata	Cobalt-60 Handling Facility	Operating
*AECL Radiochemical Co. Tunney's Pasture	Mo-99 Production Process	Operating

PRINCE EDWARD ISLAND

Radioisotopes

Number of users	5

QUEBEC

Power Reactors

Location and Licensee	Type and Capacity	Status
Gentilly 1 Nuclear Power Station (Hydro-Quebec & AECL)	CANDU-BLW 250 MW(e)	Started up 1970. Currently shut down. (Possession licence issued)

Gentilly 2 Nuclear Power Station Gentilly (Hydro-Quebec)	CANDU-PHW 600 MW(e)	Started up 1982. Operating

Heavy Water Plants

Location and Licensee	Capacity (Tonnes/Year)	Status
LaPrade Heavy Water Plant (Atomic Energy of Canada Limited)	800	Facility mothballed

Uranium Refineries and Fuel Fabrication Facilities

Location and Licensee	Capacity (Tonnes/Year Uranium)	Status
Westinghouse Canada Inc. Varennes	200 (fuel bundles)	Operating

Radioactive Waste Management Facilities

Location and Licensee	Type	Status
Gentilly 1 Nuclear Power Station (Hydro-Quebec)	Storage of solid wastes from Gentilly 1 nuclear reactor and anticipated wastes from Gentilly 2 nuclear reactor	Operating. Construction Approval in effect for an extension to the facility.

Research Reactors

Location and Licensee	Type and Capacity	Status
Ecole polytechnique Montreal	SLOWPOKE II 20 KW(t) Subcritical Assembly	Operating
" "	"	"

Particle Accelerators

Location and Licensee	Type	Status
Concordia University Montreal	Neutron Generator	Operating
Ecole polytechnique Montreal	Neutron Generator	Special Licence
Ecole polytechnique Montreal	Neutron Generator	Special Licence
Institut national de la recherche scientifique Varennes	Neutron Generator	Operating
McGill University Montreal	Synchrocyclotron	Operating
Montreal General Hospital Montreal	Linac	Operating
Montreal Neurological Institute Montreal	Cyclotron	Operating
Hotel-Dieu de Quebec Quebec	Betatron	Operating
Universite de Laval Sainte-Foy	Van de Graaff	Operating
Universite Montreal Montreal	Tandem Van de Graaff & Dynamitron	Operating

Radioisotopes

Number of users	783

SASKATCHEWAN

Uranium Mine/Mill/etc. Locations

Location and Licensee	Status
Beaverlodge Mining Operations Beaverlodge (Eldorado Resources Ltd.)	Decommissioning and Close-out
Dubyna Mine Uranium City (Eldorado Resources Ltd.)	Decommissioning and Close-out
Uranium City (A. Frame Contracting Ltd.)	Ore Removal Permit
Cluff Lake "Claude" Ore Body (Amok Ltd.)	Underground Exploration
Cluff Lake, Phase I (Amok Ltd.)	Mining Facility Operating Licensed Capacity: 1.7 million kg/yr uranium
Cluff Lake, "Uranium Project" (Amok Ltd.)	Construction
Dawn Lake (Saskatchewan Mining Development Corporation)	Ore Removal Permit
Key Lake (Key Lake Mining Corporation)	Underground Exploration
Midwest Lake (Canada Wide Mines Ltd.)	Ore Removal Permit
Rabbit Lake Mine Wollaston Lake (Gulf Minerals Canada Ltd.)	Mining Facility Operating Licensed Capacity: 2.3 million kg/yr uranium concentrate
Wollaston Lake (S.E.R.U. Nucléaire (Canada) Ltd.)	Ore Removal Permit
Wolly Lake Project (Canadian Occidental Petroleum Ltd.)	Ore Removal Permit

Uranium Refineries and Fuel Fabrication Facilities

Location and Licensee	Capacity (Tonnes/Year Uranium)	Status
Saskatchewan Research Council Saskatoon	Treatment of 10 tonnes of ore containing uranium	Operating

Research Reactors

Location and Licensee	Type and Capacity	Status
Saskatchewan Research Council Saskatoon	SLOWPOKE II 20 KW(t)	Operating

Particle Accelerators

Location and Licensee	Type	Status
Saskatoon Cancer Clinic Saskatoon	Betatron	Operating
Saskatchewan Cancer Foundation Regina	Linac	Operating
University of Saskatchewan Saskatoon	Linac	Operating

Radioisotopes

Number of users	94

NORTHWEST TERRITORIES

Radioisotopes

Number of users	9

YUKON TERRITORY

Radioisotopes

Number of users	5

NB Information based on Atomic Energy Control Board licensing. Particle Accelerators and Radioisotope User information is as of December 31, 1982. (*) indicates facility covered by AECL site licence, as of June 1982. All other information is as of March 31, 1983.

Other facilities without nuclear licences exist.

Reactor Performance Comparisons Highlight CANDU

To the end of 1982, Canada's CANDU reactors led the world (outside the COMECON group) in overall performance, as measured by annual and cumulative capacity factors. Of the top ten reactor positions over 150MW for the year 1982, CANDU reactors took five places, and of the top ten in terms of lifetime performance to the end of 1982, CANDU took six of the top ten positions. Canada's reactors over 150MW in operation for the year had achieved an average 85.6%, compared with BWRs at 61.2% and PWRs at 60.0%. In terms of lifetime performance, CANDU averaged 77.0%, with mature BWRs averaging 55.6% and PWRs, 56.0%.

Billions of "extra" revenues

The higher capacity factors for the CANDU stations should result in "extra" revenue from electricity sales in the multi-billion dollar range over the lifetime of a reactor. For example, a 10% gain in lifetime capacity factor of a 2400MW station will produce an additional $3 billion in revenue over the station lifetime based on an electricity-rate of 5¢/kWh.

Reactor Performance — For 1982 — Free World's Top Ten (over 150MW)

	Name	Country	Type	MW Gross	Capacity Factor %
1	Bruce 3	Canada	CANDU	826	97.1
2	St. Lucie 1	USA	PWR	862	94.8
3	Doel 1	Belgium	PWR	412	92.9
4	Bruce 4	Canada	CANDU	826	92.8
5	Pickering 4	Canada	CANDU	542	91.9
(Tied)	Vermont Yankee	USA	BWR	545	91.9
7	Barsebaeck 2	Sweden	BWR	600	91.4
8	Pickering 2	Canada	CANDU	542	90.9
9	Muhleberg	Switzerland	BWR	336	90.5
10	Bruce 1	Canada	CANDU	826	90.4
(Tied)	Connecticut Yankee	USA	PWR	602	90.4

Reactor Performance — Lifetime to end of December 1982 (over 150MW)

	Name	Country	Type	MW Gross	Capacity Factor %
1	Bruce 3	Canada	CANDU	826	86.5
2	Beznau 2	Switzerland	PWR	364	83.9
3	Bruce 4	Canada	CANDU	826	83.3
4	Pickering 2	Canada	CANDU	542	82.4
(Tied)	Stade 1	West Germany	PWR	662	82.4
(Tied)	Hunterston A	UK	Magnox	169	82.4*
7	Pickering 4	Canada	CANDU	542	80.6
8	Bruce 1	Canada	CANDU	826	80.3
(Tied)	Obrigheim	West Germany	PWR	345	80.3
10	Pickering 1	Canada	CANDU	542	80.0

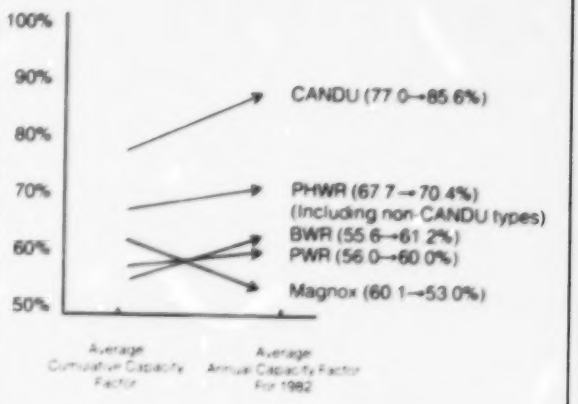
Source — Nuclear Engineering International
*Station average for two reactors

Canadian Nuclear Reactors

Name	Location	Power MW gross	Operator	Commercial Operation
In operation				
NPD	Ontario	25	OH/AECL	1962
Douglas Point	Ontario	218	OH	1968
Gentilly 1 (Shut down)	Quebec	266	HQ	1972
Pickering 1	Ontario	542	OH	1971
Pickering 2	Ontario	542	OH	1971
Pickering 3	Ontario	542	OH	1972
Pickering 4	Ontario	542	OH	1973
Bruce 1	Ontario	826	OH	1977
Bruce 2	Ontario	826	OH	1977
Bruce 3	Ontario	826	OH	1978
Bruce 4	Ontario	826	OH	1979
Point Lepreau	New Brunswick	680	NBEPC	1983
Gentilly 2	Quebec	685	HQ	1983
Pickering 5	Ontario	540	OH	1983
Under construction				
Pickering 6	Ontario	540	OH	1984
Pickering 7	Ontario	540	OH	1984
Pickering 8	Ontario	540	OH	1985
Bruce 5	Ontario	807	OH	1984
Bruce 6	Ontario	807	OH	1984
Bruce 7	Ontario	807	OH	1986
Bruce 8	Ontario	807	OH	1987
Darlington 1	Ontario	936	OH	1989
Darlington 2	Ontario	936	OH	1988
Darlington 3	Ontario	936	OH	1991
Darlington 4	Ontario	936	OH	1992

AECL — Atomic Energy of Canada Ltd
HQ — Hydro-Quebec
NBEPC — New Brunswick Electric Power Commission
OH — Ontario Hydro

Cumulative vs. Annual Performance To end of 1982 by Reactor Type



CANDU Facts

All operating CANDU reactors are of the pressurized heavy water type, using horizontal pressure tubes containing natural uranium dioxide fuel and heavy water for the moderator, heat transport and reflector. Below are selected parameters and facts concerning CANDU reactors.

	Pickering (A) Unit	Bruce (A) Unit	Typical 600 MW Unit
Owner and operator	Ontario Hydro	Ontario Hydro	—
First unit in-service	1971	1977	1983
Rated output per reactor (Gross Thermal)	1744MW	2515MW	2155MW
Electrical output (Gross)	542MW	826MW (equivalent)	675MW
Net efficiency	29%	31%	29%
Main calandria shell diameter	8.09 m	8.46 m	7.6 m
Plate thickness	25.4 mm	31.7 mm	28.6 mm
Inside length	5.94 m	5.95 m	4 m
Fuel channels (per reactor)	390	480	380
Fuel bundles per channel	12	13	12
Fuel bundles	4680	6240	4560
Fuel load (UO_2)	105 Mg	108 Mg	95 Mg
Burn-up	192 MWh/kgU	195 MWh/kgU	180 MWh/kgU
Moderator & reflector (D_2O)	301 Mg	303 Mg	263 Mg
Heat transport (D_2O)	143 Mg	300 Mg	199 Mg
Primary coolant pumps	16 (12 active)	4	4
Boilers	12	8	4

Safety

- CANDU reactor core comprises hundreds of small diameter pressure tubes, which have leak-before-break characteristics so that the effects of a failure are relatively small.
- Control devices operate within low pressure moderator, unaffected by high temperatures or pressure surges.
- Extensive heavy water detection system gives early warning of either incipient or potential failure.
- Three separate heat sinks: moderator, water-filled shield tank and emergency core cooling.
- On-power refuelling allows defective fuel to be easily removed.
- Natural uranium produces slow power rises, 1/10 rate of LWRs.
- Numerous control and emergency systems: adjuster rods, liquid zone controllers, shut-off rods, control absorbers, poison control and poison injection for shutdown, emergency core cooling, dual computer control, etc.

Miscellaneous

- Electricity generated from one CANDU fuel bundle equals that generated from 424 tonnes of coal in a coal-fired generating station or 1700 barrels of oil in an oil-fired generating station. Each bundle stays in reactor for about one year and is added and removed by on-power refuelling.
- Cost of electricity from a CANDU station in Ontario is 60% that of equivalent coal-fired electricity.
- Costs of heavy water make-up are much less than costs associated with enriched uranium replacement fuel for LWRs.
- CANDU demonstrates best uranium utilization of all commercial reactors, and has potential for many new fuel cycles.

Canada's Electricity Balance

Canada's electrical industry generated $34.6 billion of electricity, products and services and employed 250,000 people in 1980, according to the Canadian Electrical Council. Total electricity sales by utilities were $9 billion; electricity export sales to the US were $800 million. Below are generation figures for Canada from Statistics Canada showing the total generation and the nuclear component for the last two years.

Total Generation: (By utility and industry)

	1981 (MWh)		1982 (MWh)	
Hydro	263 137 421	(70%)	255 136 313	(68%)
Thermal	77 594 693	(20%)	83 897 688	(22%)
Nuclear	37 799 069	(10%)	36 414 981	(10%)
Total:	378 531 183	(100%)	375 448 982	(100%)
Imports: from US:	1 496 876		2 847 520	
Exports to U.S.				
Firm	5 008 351		5 803 397	
Secondary	30 364 068		28 410 318	
Total:	35 372 419		34 213 715	
Total Electricity Available: (Generation plus imports less exports)	344 655 640		344 082 787	

World Reactor Capacity

There were 290 completed commercial nuclear reactors worldwide at the end of 1982, with a net electrical generating capacity of 178,438 MW. Another 231 reactors were on order or under construction, with a projected capacity of 214,705 MW. These totals exclude reactors of less than 30 MW in size, and include some reactors with indefinite status.

	Reactors completed			Under Construction		
	Qty.	Type	Total MW (net)	Qty.	Type	Total MW (net)
Argentina	1	CANDU-PHWR	600	1	PHWR	692
	1	PHWR	335			
	2		935			
Austria	1	BWR	692	—	—	—
Belgium	5	PWR	3,450	2	PWR	2,000
Brazil	1	PWR	626	2	PWR	2,490
Bulgaria	4	PWR	1,760	—	—	—
Canada	1	CANDU-BLWR	250	11	CANDU-PHWR	8,072
	12	CANDU-PHWR	7,010			
	13		7,260			
China	—	—	—	1	PWR	300
Czechoslovakia	2	PWR	880	8	PWR	3,520
Egypt	—	—	—	2	PWR	1,800
Finland	2	PWR	840	—	—	—
	2	BWR	1,320			
	4		2,160			
France	23	PWR	20,150	29	PWR	32,440
	1	LMFBR	233	1	LMFBR	1,200
	1	GCHWR	70			
	7	GCR	2,205			
	32		22,658	30		33,640
Germany (East)	5	PWR	1,830	2	PWR	880
Germany (West)	7	PWR	6,604	12	PWR	15,094
	4	BWR	3,145	3	BWR	3,758
	1	PHWR	52	1	LMFBR	295
				1	THTR	296
	12		9,801	17		19,443
Hungary	1	PWR	440	3	PWR	1,320
India	2	CANDU-PHWR	404	6	PHWR	1,320
	2	BWR	400			
	4		804			
Iraq	—	—	—	1	PWR	900
Italy	1	GCR	150	1	LWCHW	40
	1	PWR	260	2	BWR	1,964
	1	BWR	875			
	3		1,285	3		2,004
Japan	11	PWR	7,504	6	PWR	4,510
	12	BWR	8,789	6	BWR	5,824
	1	GCR	159	1	LMFBR	300
	1	LWCHWR	200			
	25		16,652	13		10,634
Korea	1	PWR	556	7	PWR	6,081
	1	CANDU-PHWR	629			
	2		1,185			
Libya	—	—	—	1	PWR	300
Luxembourg	—	—	—	1	PWR	1,250
Mexico	—	—	—	2	BWR	1,308
Netherlands	1	PWR	445	—	—	—
	1	BWR	50	—	—	—
	2		495			
Pakistan	1	CANDU-PHWR	125	—	—	—
Philippines	—	—	—	1	PWR	620
Poland	—	—	—	2	PWR	880
Rumania	—	—	—	4	PWR	3,440
				2	CANDU-PHWR	1,400
				6		4,840
South Africa	—	—	—	2	PWR	1,844
Spain	4	PWR	2,893	8	PWR	7,731
	1	BWR	440	4	BWR	3,810
	1	GCR	480			
	6		3,813	12		11,541
Sweden	3	PWR	2,600	2	BWR	2,110
	7	BWR	4,700			
	10		7,300			
Switzerland	3	PWR	1,620	3	BWR	3,007
	1	BWR	320			
	4		1,940			
Taiwan	4	BWR	3,110	2	PWR	1,814
UK	26	GCR	5,206	9	AGR	5,740
	5	AGR	3,100			
	1	HWLWR	92			
	1	LMFBR	250			
	33		8,648			
USA	51	PWR	41,974	43	PWR	48,185
	27	BWR	18,895	23	BWR	24,940
	1	HTGR	330	1	LMFBR	350
	1	LGR	860			
	80		62,059	67		73,475
USSR	18	LGR	10,900	4	LGR	4,000
	12	PWR	6,015	8	PWR	6,880
	2	LMFBR	950			
	1	BWR	50	12		10,880
	33		17,915			
Yugoslavia	1	PWR	615	—	—	—

Abbreviations

AGR — Advanced gas-cooled reactor
BLWR — Boiling light water reactor
BWR — Boiling water reactor
CANDU — Canada Deuterium Uranium
GCHWR — Gas-cooled, heavy-water-moderated reactor
GCR — Gas-cooled reactor
HTGR — High-temperature, gas-cooled reactor
HWLWR — Heavy water moderated, boiling light water cooled reactor
LGR — Light-water cooled, graphite-moderated reactor
LMFBR — Liquid metal fast breeder reactor
LWCHW — Light water cooled, heavy water moderated reactor
PHWR — Pressurized heavy-water moderated and cooled reactor
PWR — Pressurized water reactor
THTR — Thorium high-temperature reactor

Source: Nuclear News, February 1983

Nuclear Directory

This Nuclear Directory contains two parts: Part 1 is the 1983 Guide to Nuclear-Related Organizations and Part 2 is the 1983 Nuclear Buyers' Guide.

Part 1 — 1983 Guide to Nuclear-Related Organizations

INTERNATIONAL ORGANIZATIONS

The following selected agencies, societies and forums deal with the various aspects of nuclear energy on an international basis.

Commission of the European Communities — Euratom
200, rue de la Loi, B-1049 Brussels, Belgium

Council for Mutual Economic Assistance (COMECON)
Prospeckt Kalinina 56
121205 Moscow, U.S.S.R.

European Atomic Energy Society
c/o Studsvik Energiteknik AB
Fack, S-61182
Nykoping, Sweden

European Nuclear Society (ENS)
P.O. Box 2613
CH-3001 Berne
Switzerland

Foratom (Forum Atomique Européen)
1 St. Alban's Street, London
SW1Y 4SL, United Kingdom

Inter-American Nuclear Energy Commission (IANEC)
General Secretary of the OAS
Washington, D.C. 20006, U.S.A.

International Atomic Energy Agency (IAEA)
Wagramerstrasse 5
P.O. Box 100
A-1400 Vienna, Austria

International Commission on Radiation Units and Measurements (ICRU)
7910 Woodmont Avenue, Suite 1016,
Bethesda, MD 20914, U.S.A.

International Commission on Radiological Protection (ICRP)
Clifton Ave.
Sutton, Surrey, SM2 5PU,
United Kingdom

International Nuclear Law Association (INLA)
29 Square de Meeus,
B-1040, Brussels, Belgium.

International Radiation Protection Association (IRPA)
B.P. No. 33, 92260
Fontenay-aux-Roses, France

Nuclear Energy Agency (NEA) of the OECD
38 boulevard Suchet, F-75016
Paris, France

Nuclear Public Relations Contact Group (NPRCG)
Via Parisiello 26-28
1-00 198 Rome, Italy

Stockholm International Peace Research Institute (SIPRI)
Sveavagen 166
S-11346,
Stockholm, Sweden

United Nations Scientific Committee on the Effects of Atomic Radiation
P.O. Box 475
A-1011 Vienna, Austria

The Uranium Institute,
New Zealand House (Eighth Floor),
Haymarket, London SW1Y 4TE,
United Kingdom

World Energy Conference (WEC),
International Executive Council,
34 St. James St.,
London, SW1A 1HD,
United Kingdom

CANADIAN ORGANIZATIONS

The following governmental and private organizations are involved with nuclear energy on a national or provincial basis.

Federal

Atomic Energy Control Board
P.O. Box 1046
Station B
Ottawa, Ontario
K1P 5S9

Atomic Energy of Canada Limited
Corporate Office
275 Slater Street
Ottawa, Ontario
K1A 0S4

Atomic Energy of Canada Limited
CANDU Operations
Sheridan Park Research Community
Mississauga, Ontario
L5K 1B2

Canada's National Standards for Nuclear Power

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- containment structures
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- decontamination
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- waste management
- terminology
- quality assurance

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Canadian Standards Association

178 Rexdale Blvd., Rexdale (Toronto), Ontario, Canada M9W 1R3

Atomic Energy of Canada Limited
CANDU Operations
1600 Dorchester Blvd. West
Montreal, Quebec
H3H 1P9

Atomic Energy of Canada Limited
Chalk River Nuclear Laboratories
Chalk River, Ontario
K0J 1J0

Atomic Energy of Canada Ltd.
Whiteshell Nuclear Research
Establishment
Pinawa, Manitoba
R0E 1L0

Atomic Energy of Canada Limited
Waste Management Information
Whiteshell Nuclear Research
Establishment
Pinawa, Manitoba
R0E 1L0

Atomic Energy of Canada Limited
Port Hawkesbury Heavy Water Plant
P.O. Box 698
Port Hawkesbury, Nova Scotia
B0E 2V9

Atomic Energy of Canada Limited
Glace Bay Heavy Water Plant
P.O. Box 5
Glace Bay, Nova Scotia
B1A 5V8

Eldorado Resources Limited
255 Albert Street, Suite 400
Ottawa, Ontario
K1P 6A9

Dept. of Energy, Mines and Resources
580 Booth Street
Ottawa, Ontario
K1A 0E4

Dept. of the Environment
Ottawa, Ontario
K1A 0H3

External Affairs Dept.
Lester B. Pearson Building
125 Sussex Drive
Ottawa, Ontario
K1A 0G2

Health & Welfare Canada
Ottawa, Ontario
K1A 0K9

National Research Council
Institute for Scientific and Technical Information
Montreal Road
Ottawa, Ontario
K1A 0R6

Science Council of Canada
100 Metcalfe Street
Ottawa, Ontario
K1P 5M1

Provincial

New Brunswick Electric Power Commission
527 King Street
Fredericton, New Brunswick
E3B 4X1

Point Lepreau Generating Station
P.O. Box 10
Lepreau, New Brunswick
E0G 2H0

Ontario Hydro (Head Office)
700 University Avenue
Toronto, Ontario
M5G 1X6

Ontario Hydro
Communications Centre
Pickering Generating Station
P.O. Box 160
Pickering, Ontario
L1V 2R5

Ontario Hydro
Communications Centre
Bruce Nuclear Power Development
P.O. Box 3000
Tiverton, Ontario
N0G 2T0

Ontario Hydro
Communications Centre
Darlington Generating Station
P.O. Box 1000
Bowmanville, Ontario
L1C 3W2

Hydro Québec
75 ouest boul. Dorchester
Montréal, Québec
H2Z 1A4

Gentilly Nuclear Power Station
C.P. 360
Gentilly, Québec
G0X 1G0

Saskatchewan Mining Development Corporation
Public Affairs
8th Floor, Provincial Building
122 - 3rd Avenue North
Saskatoon, Saskatchewan
S7K 2H6

Associations

Association for the Advancement of Science in Canada (AASC)
805 - 151 Slater St.
Ottawa, Ontario
K1P 5H3

Canadian Association of Nuclear Medicine
1440 St. Catherine St. W.
Suite 806
Montreal, Quebec
H3G 1R8

Canadian Institute for Radiation Safety
Box 460
Elliot Lake, Ontario
P5A 2J9

Canadian Nuclear Association
111 Elizabeth Street, 11th Floor
Toronto, Ontario
M5G 1P7

Canadian Nuclear Society (The Technical Society of the CNA)
111 Elizabeth Street, 11th Floor
Toronto, Ontario
M5G 1P7

Canadian Radiation Protection Association
P.O. Box 3291, Station D
Ottawa, Ontario
K1P 6H8

Canadian Standards Association
178 Rexdale Blvd.
Rexdale (Toronto), Ontario
M9W 1R3

Organization of CANDU Industries

We are a non-profit organization, formed in 1979, with a membership of some 40 of the leading Canadian companies in the private sector engaged in the supply of goods and related services for the CANDU Nuclear Steam Plant for the export market.

O.C.I. acts as a coordinator of necessary activities, not as a contracting organization, in providing private sector marketing expertise to the CANDU export effort. We provide a focal point for A.E.C.L. and prospective customers to relate to the important Canadian nuclear supply industry.

Assistance available to prospective foreign purchasers of the CANDU reactor includes:

- familiarization with Canadian know-how in design and manufacture of nuclear grade components and consulting engineering services through visits in Canada and abroad
- assessment of the potential of the local industry to build CANDU Nuclear Steam Plants
- provide the vehicle by which the transfer of Canadian technology may be discussed and arranged.

Head Office: **Suite 1400,**
One Yonge Street,
Toronto, Ont.
M5E 1J9

Telephone 416-363-7261
Telex 065-24693

Engineering Institute of Canada (and its constituent societies)
2050 Mansfield St.
Montreal, Quebec
H3A 1Z2

Nuclear Insurance Association of Canada
180 Dundas St. W.
Toronto, Ontario
M5G 1Z9

Organization of CANDU Industries
Suite 1400, One Yonge St.
Toronto, Ontario
M5E 1J9

NATIONAL ORGANIZATIONS IN OTHER COUNTRIES

The following selected governmental and private organizations deal with nuclear energy within their country.

Atomic Energy Commission
Faculty of Science, Kabul University, Kabul
Afghanistan.

Centre des Sciences et de la Technologie Nucléaires (CSTN)
B.P. 1017, Alger-Gare
Algeria.

Comision Nacional de Energia Atomica (CNEA)
Avda del Libertador 8250
1429 Buenos Aires
Argentina.

Australian Atomic Energy Commission
Lucas Heights
Research Lab.
New Illawarra Rd.
Lucas Heights
Private Mail Bag
Sutherland 2232, N.S.W.
Australia.

Uranium Information Centre Ltd.
Box 1649N, G.P.O.
Melbourne, Vic. 3001
Australia.

Osterreichische Kerntechnische Gesellschaft (Austrian Nuclear Society)
Schuttelstrasses 115, A-1020 Wien
Austria.

Osterreichisches Forschungszentrum Seibersdorf Ges. m.b.H.
(Austrian Research Centre Seibersdorf)
1082 Vienna, Lenaugasse 10
Austria.

Osterreichisches Atomforum
Mariahilferstrasse 32
A-1071
Vienna
Austria.

Bangladesh Atomic Energy Commission
P.O. Box No. 158
Ramna, Dacca-2
Bangladesh.

Belgian Nuclear Society,
Ravensteinstreet, 3, B-1000
Brussels,
Belgium.

Commissariat à l'Energie Atomique (Atomic Energy Commission),
Rue de Mot 30,
1040 Brussels
Belgium.

Forum Nucléaire Belge (ASBL)
Rue de la Pépinière 36,
B-1000, Bruxelles
Belgium.

Comision Boliviana de Energie Nuclear
Avda 6 de Agosto 2905,
P.O.B. 4821, La Paz
Bolivia.

Commissao Nacional de Energia Nuclear (CNEN)
Rua General Severiano 90,
Rio de Janiero
Brazil.

Bulgaria Committee for the Peaceful Uses of Atomic Energy
Slavianska 8,
Sofia
Bulgaria.

Comision Chilena de Energia Nuclear
Los Jesuitas 645,
Casilla 188-D, Santiago
Chile.

Atomic Energy Institute
Academia Sinica, Beijing
China, (Peoples' Republic)

Atomic Energy Council
67, Lane 144,
Keelung Road, Sec. 4
Taipei
China, (Taiwan)

Instituto de Asuntos Nucleares — IAN
Avda Aeropuerto El Dorado
Carrera 50
Apdo Aereo 8595, Bogota
Columbia.

Comission de Energia Atomica,
Apdo — Postal 6681, San Jose,
Costa Rica.

Comision Nacional para el Uso Pacifico de la Energia Atomica,
Apdo — 2169, Havana 2,
Cuba

Czechoslovak Atomic Energy Commission (CSKAE),
Slezska 9, 120 29 Prague 2,
Czechoslovakia.

Danish Energy Agency,
Landemaerket 11,
DK-1119
Copenhagen K,
Denmark.

Danatom (Selskabet for Atomenergiens Industrielle Udnyttelse),
Allegade 2, P.O. Box 106,
DK-3000
Helsingor,
Denmark.

Comision Nacional de Asuntos Nucleares,
Edificio de la Defensa Civil,
Dr. Delgado 58,
Santa Domingo,
Dominican Republic.

Comision Ecuatoriana de Energia Atomica,
Cordero 779Y Avda. 6 de Diciembre,
Quito, Casilla 2517,
Ecuador.

Atomic Energy Organization,
101 Kasr El-Eini St.,
Cairo,
Egypt.

Comision Salvadorena de Energia Nuclear,
San Salvador,
El Salvador.

Atomic Energy Commission,
Ministry of Trade and Industry,
Energy Department
Pohjoinen Makasiinikatu 6
SF-00130 Helsinki 13
Finland.

(Finnish Nuclear Society)
Suomen Atomiteknillinen,
Seura-Atomtekniska Saliskapet i,
Finland r.y.,
c/o Teollisuuden Voima Oy,
SF-27160
Olkiluoto
Finland.

Le Commissariat à l'Energie Atomique (CEA),
Atomic Energy Commissariat
31-33 rue de la Fédération,
F-75752 Cedex 15,
France.

Forum Atomique Français,
48 rue de la Procession,
F-75015, Paris,
France.

SFEN (Société Française d'Energie Nucléaire),
48 rue de la Procession,
F-75016, Paris,
France.

Staatliches Amt Fur Atomsicherheit und Strahlenschutz der D.D.R.
(Board of Nuclear Safety and Radiation Protection of the G.D.R.),
1157 Berlin-Karlshorst,
Waldowallee 117,
East Germany.

Bundesministerium Fur Forchung und Technologie (Federal Ministry for Research and Technology),
5300, Bonn 2,
Heinemannstrasse 2,
West Germany.

DATF (Deutsches Atomforum e.v.),
Heussallee 10, D-5300 Bonn,
West Germany.

Kerntechnische Gesellschaft e.V.-KTG (German Nuclear Society),
Heussallee 10, D-5300, Bonn,
West Germany.

Greek Atomic Energy Commission (Elliniki Epitropi Atomikis Energias),
Aghia Paraskevi,
Attikis, Athens,
Greece.

Hellenic Nuclear Society,
NRC Democritos,
Aghia Paraskevi,
Attikis, Athens,
Greece.

Direccion General de Energia Nuclear
Diagonal 17 29-78
Zona 11, Apdo. 1421
Guatemala City,
Guatemala.

Comision Hondurena de Energia Atomica,
Apdo 104, Tegucigalpa,
Honduras.

Orszagos Atomenergia Bizottsag,
(National Atomic Energy Commission), H-1374 Budapest 5, P.O.B. 565,
Hungary.

Chhatrapati Shivaji Maharaj Marg,
(Atomic Energy Commission),
Bombay 400 039,
India.

Badan Tenaga Atom Nasional,
(National Atomic Energy Agency),
Jalan KH Abdul Rokhim,
Kuningan Barat
Mampang Prapatan
P.O.B. 85 KBY
Jakarta Selatan,
Indonesia.

Atomic Energy Organization of Iran,
P.O.B. 12-1198, Teheran,
Iran.

Israel Atomic Energy Commission,
26 Rehov Hauniversitah,
P.O. Box 7061,
Tel-Aviv,
Israel.

ENEA
Via Regina Margherita 125,
00198 Rome,
Italy.

Forum Italiano Deli Energia Nucleare (FIEN),
(Italian Nuclear Energy Forum),
Via Paisiello, 26/28, 00198 Rome,
Italy.

Societa Nucleare Italiana
(Italian Nuclear Society),
c/o Impianti Nucleari,
Viale Risorgimento 2,
I-40136,
Bologna
Italy.

Japan Atomic Energy Commission (JAEC),
2-2-1 Kasumigaseki,
Chiyoda-Ku, Tokyo,
Japan.

Japan Atomic Industrial Forum (JAIF),
Toshin Bldg., 1-13,
Shimbashi 1-chome,
Minato-ku, Tokyo 105,
Japan.

Atomic Energy Commission,
Ministry of Science and Technology,
Sejong Ro, Chongro-Ku, Seoul 110,
Republic of Korea.

Kuwait Nuclear Energy Committee,
Ministry of Electricity & Water,
P.O. Box 12 & 54,
Kuwait.

Atomic Energy Establishment,
P.O. Box 397, Tripoli,
Libya.

Conseil National de l'Energie Nucléaire (CNEN).
(National Nuclear Energy Council).
Ministère de l'Energie.
19 blvd. Royal, Luxembourg-Ville.
Luxembourg.

Centro de Informacion Y.
Documentacion Nuclear.
Insurgentes Sur 1079 (Planta Baja).
Delegacion Benito Juarez.
Mexico, D.F.

Industrial Council for Nuclear Energy.
Bezuidenhoutseweg 6.
The Hague.
Netherlands.

Nederlands Atoomforum.
Scheveningse Weg 112.
The Hague.
Netherlands.

Netherlands Nuclear Society.
c/o N.V. KEMA.
Utrechtseweg 310.
NL-6812 AR Arnheim.
Netherlands.

New Zealand Atomic Energy Committee.
c/o D.S.I.R., Private Bag, Lower Hutt.
New Zealand.

IFE (Institute for Energiteknikk).
P.O.B. 40, 2007 Kjeller.
Norway.

Norsk Atomforum.
c/o Scandpower AS.
P.O. Box 3, N-2007 Kjeller.
Norway.

Pakistan Atomic Energy Commission.
P.O.B. 1114.
Islamabad.
Pakistan.

Comision Nacional de Energia Atomica.
Ministerio de Relaciones Exteriores.
Asuncion.
Paraguay.

Instituto Peruano de Energia Nuclear (IPEN). Av. E. Canabal.
Moreyra 425.
Lima.
Peru.

Philippine Atomic Energy Commission.
P.O. Box 932.
Manila.
Philippines.

Energetyki Energii Atomowej.
Ministry of Energetics and Atomic Energy, Mysia 2, 00 955 Warsaw.
Poland.

Direccao Geral de Energia.
Departamento de Energia Nuclear.
Avenida da Republica 45-5°.
Lisbon 1000.
Portugal.

Puerto Rico Nuclear Center.
Bio-Medical Bldg.
Cabara Heights Station.
San Juan, 00922.
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State Committee for Nuclear Energy.
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Bucharest-Magurele.
Sector 5.
Romania.

Atomic Energy Corp.
Private Bag X256.
Pretoria, 0001.
South Africa.

Junta De Energia Nuclear.
(Atomic Energy Board).
Avda Complutense 22.
Ciudad Universitaria.
Madrid 3.
Spain.

Forum Atomico Espano.
Boix y Morer, 6.
Madrid 3.
Spain.

Sociedad Nuclear Espanola.
(Spanish Nuclear Society).
Estebanez Calderon.
7-9 F. E-Madrid-20.
Spain.

Foreningen Kärnteknik.
(Swedish Nuclear Society).
c/o RFS, Box 5864.
S-10248 Stockholm.
Sweden.

Swedish Atomic Forum.
Box 5506, S-114 85.
Stockholm.
Sweden.

Swedish Nuclear Power Inspectorate.
Box 27106.
S-10252 Stockholm 43.
Sweden.

Bundesamt fur Energiewirtschaft.
(Federal Office of Energy).
CH-3003.
Berne.
Switzerland.

Schweizerisch Gesellschaft der Kernfachleute.
(Swiss Nuclear Society).
c/o Eidg. Institut fur Reaktorforschung, CH-5303.
Wurenlingen.
Switzerland.

Schweizerische Vereinigung fur Atomenergie (SVA).
(Swiss Association for Atomic Energy).
Barenplatz 2, Postfach 2613.
3001 Bern.
Switzerland.

Tuluye Atom Enerjisi Kurumu.
(Turkish Atomic Energy Authority).
Karanfil Sok.
No. 67.
Bakanliklar, Ankara.
Turkey.

Turkiye Nukleer Enerji Kurumu.
(Turkish Nuclear Energy Forum).
P.O. Box 37, Bakanliklar.
Ankara.
Turkey.

State Committee for Atomic Energy.
Staromonetny pereulok 26.
Moscow 109180.
U.S.S.R.

United Kingdom Atomic Energy Authority (UKAEA).
11 Charles II St.
London, SW1Y 4QP.
United Kingdom.

British Nuclear Energy Society.
1-7 Great George St.
London, SW1P 3AA.
United Kingdom.

British Nuclear Forum.
1 St. Alban's Street.
London, SW1Y 4SL.
United Kingdom.

British Nuclear Fuels Ltd. (BNFL).
Risley, Warrington.
Cheshire, WA3 6AS.
United Kingdom.

Central Electricity Generating Board (CEGB).
Sudbury House.
15 Newgate St.
London EC1A 7AU.
United Kingdom.

Nuclear Regulatory Commission (NRC).
1717 H. St., Washington.
DC 20555.
U.S.A.

Department of Energy.
1000 Independence Ave. S.W.
Washington, DC 20585.
U.S.A.

American Nuclear Society.
555 North Kensington Avenue.
La Grange Park, IL 60525.
U.S.A.

Atomic Industrial Forum.
7101 Wisconsin Avenue.
Bethesda, MD 20814.
U.S.A.

Edison Electric Institute.
1111 19th St. N.W.
Washington, DC 20036.
U.S.A.

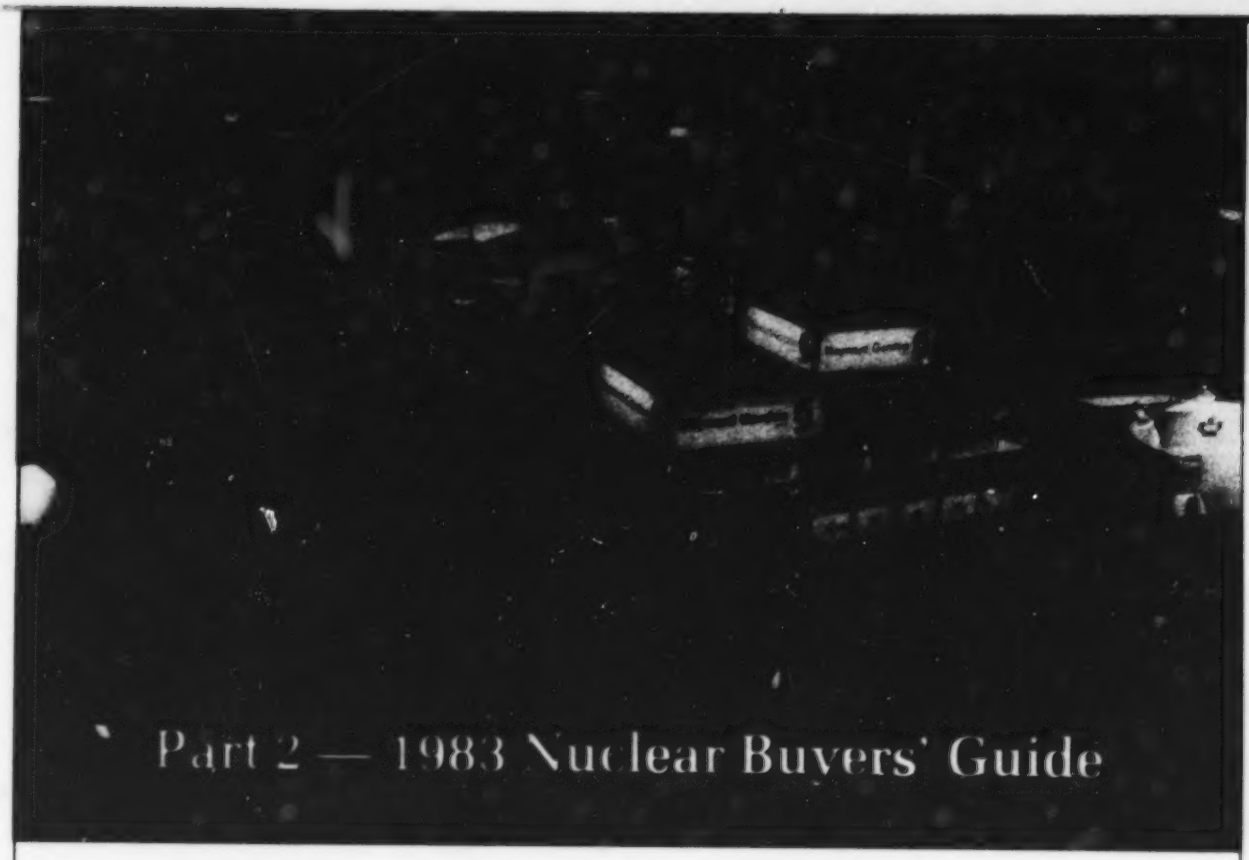
Electric Power Research Institute (EPRI).
3412 Hillview Avenue.
P.O. Box 10412.
Palo Alto, CA 94303.
U.S.A.

Comision Nacional de Energia Atomica.
Soriano 1014.
Montevideo.
Uruguay.

Consejo Nacional para el Desarrollo de la Industria Nuclear.
Apdo 68233, Caracas 1062.
Venezuela.

Strucna Sekcija za Nuklearnu Tehniku Tehnologiju ETAN-a.
(The Professional Section of ETAN for Nuclear Technique and Technology — PSENTT).
c/o Institut Josef Stefan.
P.O. Box 199, Y-61001.
Ljubljana.
Yugoslavia.

Federal Administration for International Scientific, Educational, Cultural and Technical Co-operation.
11000 Belgrade.
Kosancićev Venac 29.
Yugoslavia.



Part 2 — 1983 Nuclear Buyers' Guide

The first section of the Buyers' Guide gives the sources of supply for 202 categories of nuclear products, materials and services. This is followed by a directory of suppliers' names and addresses, the name and address of the Canadian representative of non-domestic companies, and the name and phone number of the person to contact. In cases where non-domestic companies have no Canadian representative listed, contact should be made directly with the company. These companies have indicated their intention of marketing in Canada.

While the Canadian Nuclear Association cannot accept responsibility for any errors or omission, it would appreciate comments, corrections and additions for future issues.

Nuclear products, materials and services

A

Absorbers, nuclear radiation
- Canadian General Electric
- Flanders Filters
- Nuclear Supply
- Reactor Experiments
- Technical Marketing Associates

Accelerator equipment
- Allan Crawford Associates
- Babcock & Wilcox Canada •
- National Electrostatics

Accelerators, therapeutic
- Atomic Energy of Canada — Radiochemical •
- W C Investments

Access controls
- *see Alarm Systems*
- *see Security Systems*

Activation analysis service
- Atomic Energy of Canada — Radiochemical •
- EG & G ORTEC
- McMaster University
- Nuclear Activation Services
- W C Investments

Alarm systems
- Acoustic Emission Technology
- Armatek Controls
- ASW Controls & Instruments
- Barringer Research
- Bienkhorn and Sawle
- Davis Controls
- Durmitor
- Eberline Instrument
- Federal Laboratories
- Honeywell
- Institut Dr. Foerster GmbH
- Intertechnology
- Krautkramer-Branson
- The Mosler Safe
- Non Destructive Testing Products
- The Protectowire
- Racon
- Rich Seifert & Co
- Rochester Instrument Systems
- Rosemount Instruments
- Serdula Systems
- Sutherland-Schultz
- Technical Marketing Associates
- Tennelec •
- Tracon Engineering
- Versatile Measuring Instruments
- W C Investments
- Willer Engineering

Alarm systems sensors
- Acoustic Emission Technology
- Andec Mfg •
- Armatek Controls
- ASW Controls & Instruments
- Automec, Div. of BG CHECO
- Durmitor
- Enercorp Instruments
- Federal Laboratories
- Honeywell
- Institut Dr. Foerster GmbH

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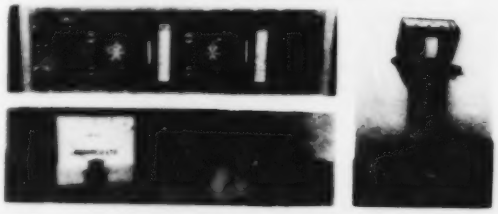

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see Engineering Construction

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Containers, radiation shielding
Atkinson Steel
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The Canada Metal Company
Corporation Outils Québec (Quebec Tools)
Dominion Bridge-Sulzer
• Ecolaire Canada
• Eldorado Resources
Gravatom Industries
Non Destructive Testing Products
Nuclear Packaging
The Nucleus
Pendar Controls
• Ralfor Steel
Reactor Experiments

Containers, shipping
see Spent Fuel Shipping Containers

Containment structures, reactor
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Combustion Engineering-Super
Dominion Bridge-Sulzer
• Ecolaire Canada
Horton CBI
Intertechnology
Pullman Power Products of Canada
• Ralfor Steel
Spectrum Engineering
Sulzer Canada
TIW Industries

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see Maintenance, Contract

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Bristol Aerospace
• Canadian General Electric
Hawker Siddeley — Orenda

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Bristol Aerospace
Hitachi (Canadian)
Standard-Modern Technologies

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Bailey Controls
CAE Electronics
• Consolidated Controls
Durmitor
Fischer & Porter (Canada)
Honeywell
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Tracon Engineering
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D

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DATE	REACTOR AND SYSTEM	AVERAGE RADIATION FIELD BEFORE DECON (mR/h)	AFTER DECON (mR/h)	AVERAGE DF
1975	Douglas Point CANDU-PHW			
	Entire primary system including fuel	3,500	560	6.2
1978	Bruce A CANDU-PHW			
	Heat exchangers	20	4	5.0
1979	Vermont Yankee BWR			
	Reactor water cleanup system	455	91	5.0
1980	Brunswick II BWR			
	Reactor water cleanup system	407	76	5.3
1981	Mine Hills Point BWR			
	Fine recirculation pumps			
	External readings	262	34	7.7
	Internal readings	570	14	41
	All readings	358	32	9.6
1981	Brunswick I BWR			
	Reactor water cleanup system	365	22	16
1981	Vermont Yankee BWR			
	Reactor water cleanup system	165	21	4.4
1982	Point Beach II PWR			
	Steam generator secondary system	555	125	4.5
1982	Mine Hills Point BWR			
	Recirculation system			
	Piping			
	Pump A	65	12	11
	Pump B	255	14	18
	Pump C	267	23	12

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Gravatom Industries
Ionex Research
• London Nuclear
Nuclear Technology (NUTEK)
Quinel International
Suntral Services

Design, nuclear facilities
see Consultants, Design

Detectors, radiation
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Alphanuclear
Aptec Engineering
Baird
Balteau Electric
Barringer Research
Canadian Astronautics
• Canadian Institute for Radiation Safety
• Dosimeter
Eberline Instruments
EDA Instruments
EG & G Instruments
EG & G ORTEC
Exploranium/Geometrics
GA Technologies/Torrey Pines
Helgeson Nuclear Services
Isotopen-Technik Dr Sauerwein GmbH
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• Labserco
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Non Destructive Testing Products
Nuclear Measurements
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Sutherland-Schultz
Tracon Engineering
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DSMA ATCON
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Balteau Electric
Barringer Research
Canadian Astronautics
• Dosimeter
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• Keithley Instruments
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E

Economic analysis
see Consultants, Economic

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- Dosimeter
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  The Presray
- Ralfor Steel
  Taylor Forge Canada
  Tube Turns
  Universal Flexible of Canada

F

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  Gamma-Metrics
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IRT

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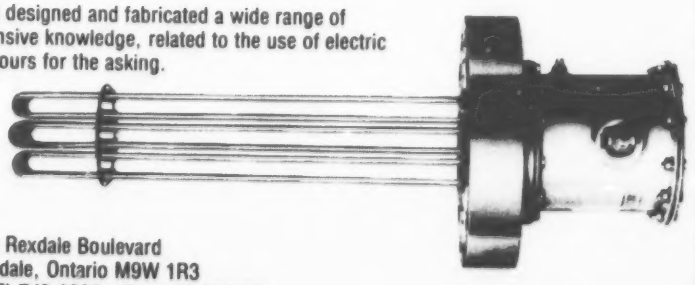

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see Consultants, Geotechnical

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- R. Laborie Associates
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- Non Destructive Testing Products
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- Tektrend International
- United Engineers & Constructors
- Universal Pipe Line Enterprises
- Wyle Laboratories

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- Replaceable or potted cables and sleeves
- Straight or Flexible bodies
- Replaceable centering guides
- Custom Shapes and Fixtures
- Manual or Computer controlled Drive systems

Contact us for assistance in probe selection to solve your testing problems.

CANADA'S MANUFACTURER OF EDDY CURRENT PROBES AND INLINE N.D.E. TESTING SYSTEMS

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Unitron Instruments
P.F. Vermeer
Versatile Measuring Instruments
W.C. Investments
Weed Instrument
Willer Engineering
Wyle Laboratories

Insulation, radiation
Raychem (Canada)

Insurance, nuclear
Johnson & Higgins Willis Faber
Marsh & McLennan
Nuclear Insurance Brokerage Service
Reed Stenhouse
Sedgwick Alexander

Ion exchange
• Labserco
The Permutit Company of Canada

Ion sources
National Electrostatics

Irradiation services
• Atomic Energy of Canada — Research
• Atomic Energy of Canada — Radiochemical
McMaster University

L

Laboratories, aerodynamic
• Atcon Services
DSMA ACTON

Laboratories, biological
Acres Consulting Services
• Atomic Energy of Canada — Research
Controls for Environmental Pollution
Micro Metallurgical

Laboratories, chemical
• Atomic Energy of Canada — Research
• Babcock & Wilcox Canada
Controls for Environmental Pollution
Eberline Instruments
MacLaren Plansearch
Nuclear Activation Services
S-Cubed

Laboratories, hydraulic
Acres Consulting Services
• Babcock & Wilcox Canada
DSMA ATCON
Wyle Laboratories

Laundry, contaminated clothing
Hitachi (Canadian)
• Radiomics Scientific

Lead
Aptec Engineering
The Canada Metal Company
Corporation Outils Québec (Quebec Tools)
Gravatom Industries
Leico Industries
The Nucleus
Technical Marketing Associates

Leak detectors
Acoustic Emission Technology
Adanac Research
ASW Controls & Instruments
Automec, Div. of BG CHECO
Avon Valve & Fitting Company
• Canadian General Electric
Crawford Fittings (Canada)
• Labserco
• Radiomics Scientific
S-Cubed
Technical Marketing Associates
Tektrend International
W.C. Investments

Level controllers, nuclear quality
Endress & Hauser
Fischer & Porter
Masoneilan of Canada
Willer Engineering

Lubricants, radiation resistant
Adanac Research
Merriman

M

Machining, nuclear quality
Anderson Metal Industries
• Atomic Energy of Canada — Radiochemical
• Babcock & Wilcox Canada
• Bata Engineering
BB Howden
B.C. Instruments
Bristol Aerospace
• Canadian General Electric
College Tool & Die
Combustion Engineering-Super
Corporation Outils Québec (Quebec Tools)
Dominion Bridge-Sulzer
Doniee Nuclear
Fahramet
Gravatom Industries
Hawker Siddeley — Orenda
Horn W.J. Industries
Lefebvre Frères
Marine Industries
N.O.W. & Associates
Numet Engineering
Standard-Modern Technologies
Strite Industries
• Versatile Vickers
Vicom
E.H. Wachs

Maintenance equipment
American Building Maintenance Industries
• Atcon Services
• Babcock & Wilcox Canada
• Canadian General Electric
Cayuga Mfg.
Combustion Engineering-Super
Inter-City Welding Supplies
Institut Dr. Foerster GmbH
Instruspec
IRD Mechanalysis
Justram Equipment
Krautkramer-Branson
Lennox Instruments
Numet Engineering
Parker Research
Quinel International
• Remote Technology
Rich Seifert & Company
S & S XRAY Products
Sinclair Macdonald Products
Standard-Modern Technologies
Tiede GmbH
E.H. Wachs
W.C. Investments

Maintenance services
American Building Maintenance Industries
Associated Kellogg
• Atcon Services
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BB Howden
• Canadian General Electric
Canadian Mine Services
Combustion Engineering-Super
K.B. Aerotech
Lummus Canada
Nicholls-Radtke & Associates
PFP Installations
Pullman Power Products of Canada
Sinclair Macdonald Products
Stearns Catalytic
Thomson Gordon
TIW Industries
United Engineers & Constructors
Universal Pipe Line Enterprises
Wyle Laboratories

Management analysis
see Consultants, Management

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Reu'ter Stokes
(roi'tur stōks), n

1. a synonym for in-core neutron detectors:

R S

(a) in 43 power reactors throughout the world
(b) designs for BWR, CANDU, and PWR type reactors
(c) fission chambers: fixed and moveable
(d) self-powered neutron detectors (SPND): Rhodium, Vanadium, Plantinum, Cobalt; fixed and moveable
(e) local-power radiation monitors (LPRM): standard and regenerative
(f) nuclear reactor-grade thermocouple

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Manipulators, remote
- Atcon Services
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- Brown Boveri Canada
- Canadian General Electric
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- Hitachi (Canadian)
- Lefebvre Freres
- Remote Technology
- Spar Aerospace
- Teleoperator Systems

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Medical instrumentation
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- Eberline Instruments
- Labserco
- Medtronic/Medical Data Systems
- The Nucleus
- Picker International Canada
- Radionics Scientific
- Technical Marketing Associates

Metal fabrications, nuclear
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- BB Howden
- Bristol Aerospace
- Canadian General Electric
- Combustion Engineering-Superior
- Corporation Outils Quebec (Quebec Tools)
- DAF Indal
- Dominion Bridge-Sulzer
- Ecolaire Canada
- Eldorado Resources
- Foster Wheeler
- Gravatom Industries
- Hawker Siddeley — Orenda
- Lefebvre Freres
- Marine Industries
- Robert Mitchell
- Nicholls-Radtke & Associates
- N O W & Associates
- Numet Engineering
- Ralfor Steel
- Taylor Forge Canada
- TIW Industries
- Tube Turns
- Versatile Vickers
- W C Investments

Monitors, area, gamma
- Allan Crawford Associates
- Aptec Engineering
- Barringer Research
- Dosimeter
- Eberline Instruments
- EDA Instruments
- EG & G Instruments
- EG & G ORTEC
- Ionex Research
- Labserco
- LND
- Ludlum Measurements
- Non Destructive Testing Products
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- Radionics Scientific
- Reuter-Stokes Canada
- Scintrex
- Technical Marketing Associates

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- Accusonic Div. Ferranti O R E
- Aptec Engineering
- Beckman Instruments
- Eberline Instruments
- EG & G ORTEC
- Hi-Q Filter Products
- Ionex Research
- IRT
- Labserco
- LND
- MSE Engineering Systems
- Nuclear Measurements
- Radionics Scientific
- Technical Marketing Associates

Monitors, radiation, general
- Alphanuclear
- Aptec Engineering
- Baird
- Canadian Astronautics
- Dosimeter
- Eberline Instruments
- EDA Instruments
- EG & G Instruments
- EG & G ORTEC
- Helgeson Nuclear Services
- Ionex Research
- IRT
- Keithley Instruments
- Labserco
- LND
- Ludlum Measurements
- Non Destructive Testing Products
- Nuclear Measurements
- The Nucleus
- Pylon Electronic Development Company
- Radionics Scientific
- Reuter-Stokes Canada
- Scintrex
- Technical Marketing Associates
- Tennelec
- W C Investments

Monitors, radiation, portal
- Aptec Engineering
- Eberline Instruments
- Helgeson Nuclear Services
- IRT
- Labserco
- LND
- Ludlum Measurements
- Pylon Electronic Development Company
- Radionics Scientific
- Technical Marketing Associates

N

Neutron activation analysis services
- Atomic Energy of Canada — Radiochemical
- EG & G ORTEC
- IRT
- McMaster University
- Nuclear Activation Services
- Nuclear Science Center

Neutron flux mapping systems
- LND
- Nuclear Supply
- Reactor Experiments
- Reuter-Stokes Canada

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O

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- Avon Valve & Fitting Company
- Byron Jackson Div. Borg Warner (Canada)
- Canadian Worcester Controls
- GH — Bettis
- Hoke Controls
- Hopkinsons
- Masonellan of Canada
- Sulzer Canada
- Taylor Forge Canada

P

Packing, mechanical, nuclear grade
- Crane Packing Company
- Durametallic Canada
- EG & G Sealol Canada
- The Presray
- Thomson Gordon

Panels, fuelling machine interface control
- Blenkhorn and Sawle
- Canadian General Electric
- Honeywell
- Sutherland-Schultz
- Tracon Engineering
- W C Investments

Penetrations, containment, electrical
- Associated Piping & Engineering
- Ceramaseal
- Enercorp
- Hitachi (Canadian)
- London Nuclear
- Numet Engineering
- Tube Turns

Penetrations, containment, mechanical
- Associated Piping & Engineering
- Bristol Aerospace
- Ecolaire Canada
- Gravatom Industries
- Hitachi (Canadian)
- Hoke Controls
- Numet Engineering
- Taylor Forge Canada
- Tube Turns

Phantoms, radiation-dosimetry
- EG & G ORTEC
- Keithley Instruments
- Radionics Scientific

Pipe fittings, nuclear grade
- Aeroquip (Canada)
- Atlas Alloys, Div. of Rio Algom
- Avon Valve & Fitting Company
- B C Instruments
- Capital Pipe & Steel Products
- Crawford Fittings (Canada)
- Ezeflow
- Jarda Forgings & Castings Sales
- Robert Mitchell
- Nicholls-Radtke & Associates
- Parker-Hannifin (Canada)
- Raychem (Canada)
- Robvon Backing Ring
- Standard Steel
- Swepco Tube
- Taylor Forge Canada
- Tube Turns
- Vereinigte Deutsche Metallwerke Canada
- Vicom

Piping, analysis
- Babcock & Wilcox Canada
- Bergen-Paterson Pipe Support
- Canadian General Electric
- Canatom
- CECO Consultants
- Control Data
- DSMA ATCON
- W P London & Associates
- Pullman Power Products of Canada
- SRDC
- Stern Industrie
- W L Wardrop & Associates

Piping, nuclear grade
- Associated Piping & Engineering
- Atlas Alloys, Div. of Rio Algom
- Capital Pipe & Steel Products
- Canadian General Electric
- Dominion Bridge-Sulzer
- Jarda Forgings & Castings Sales
- Robert Mitchell
- Nicholls-Radtke & Associates
- Nor-Sand Metals

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If it's there, IRT contamination monitors will find it.

Now there's a complete line of contamination monitors for people, tools, laundry, waste, vehicles, or just about anything else that leaves your facility. Field-proven and reliable, IRT monitors close all the gaps in a utility's Radiation Protection Program.

Laundry, Waste & Tools.

Every facility wants to eliminate expensive, time-consuming and incomplete hand monitoring of potentially contaminated materials of all kinds. IRT's ACM-600 Automated Contamination Monitor does it all, at speeds up to 600 ft/min. For everything that will fit on its 24-inch wide stainless steel mesh conveyor. Lab coats, booties, waste, toolboxes, even long objects such as ladders or scaffolding can be monitored with ease.

Vehicles.

To prevent inadvertent movement of contaminated material to uncontrolled areas, the IRT PRM-120T Truck Monitor uses sensitive, proven liquid scintillators to detect even minute amounts of radioactivity. The detectors are environmentally hardened for year-round outside operation.

Emergency Response.

For on-the-spot field measurements of just about anything radioactive, the IRT RSAM-100 Survey Assay Instrument uses a powerful programmable calculator to provide instant direct readings. It automatically converts counts into quantities such as microcuries or dpm and prints them for a hard copy. This battery-operated, self-contained system is used with a variety of gamma-ray or neutron detectors to determine contamination levels, iodine content or neutron flux.

Personnel.

It's a proven fact that better detection leads directly to lower personnel exposure. And there's no better detection than IRT's high-sensitivity, fully automatic PRM-120D Portal Radiation Monitors. They're easily capable of checking 40-50 persons per minute with an extremely low false alarm rate.

We'll send you the full story about the latest word in contamination monitoring.

IRT Corporation

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• Versatile Vickers

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Associated Pipe & Engineering
• Babcock & Wilcox Canada
Bergen-Paterson Pipe Support
Diamond Canapower
Dominion Bridge-Sulzer
• Ecolaire Canada
Foster Wheeler
Robert Mitchell
Nicholls-Radtke & Associates
Stauff
Universal Pipe Line Enterprises

Pumps, reactor
• Atcon Services
Bristol Aerospace
Dominion Bridge-Sulzer
Seal Master
Standard-Modern Technologies

Pneumatic control systems
• Atomic Energy of Canada — Radiochemical
Bailey Controls
Davis Controls
Honeywell
Masoneilan of Canada
Sutherland-Schultz
Tracon Engineering
United Electric Controls (Canada)
W C Investments
Willer Engineering

Ports, penetration
Bristol Aerospace
Gravatom Industries
Numet Engineering
Tube Turns

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Acres Consulting Services
• Atomic Energy of Canada — Candu Operations
Bechtel Canada
Brown Boveri Canada
• Canadian General Electric
• Canatom
Marine Industries

Power plants, nuclear, experience information service
• Atomic Energy of Canada — Candu Operations
Serdula Systems
The S M Stoller

Power plants, nuclear construction
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Associated Kellogg
Bechtel Canada
Dominion Bridge-Sulzer
Pullman Power Products of Canada
United Engineers & Constructors
Universal Pipe Line Enterprises

Pressure tubes
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Pressurizers, reactor
Combustion Engineering-Super
Dominion Bridge-Sulzer
Horton CBI
• Versatile Vickers

Project management services
Acres Consulting Services
Alexander & Associates
Associated Kellogg
• Atcon Services
• Atomic Energy of Canada — Candu Operations
Bechtel Canada
Canadian Mine Services
Control Data Canada
Dominion Bridge-Sulzer
DSMA ATCON
The Foundation Company of Canada
Norman W Francis
Fischer & Porter (Canada)
Gravatom Industries
Klohn Leonoff Consultants
W P London & Associates
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Lummus Canada
MacLaren Engineers
Pullman Power Products of Canada
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Dresser Canada
Duriron Canada
Fryston Associates Company
Hayward Tyler Pump
Hitachi (Canadian)
Ingersoll Rand Canada
Lawrence Pump & Engine
Marine Industries
• Sihi Pumps
Technical Marketing Associates
Union Pump (Canada)

Q

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Acoustic Emission Technology
Acres Consulting Services
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Associated Kellogg
• Atcon Services
Atlas Testing Labs & Service (Oakville)
• Babcock & Wilcox Canada
• Canadian General Electric
• Canatom
CECO Consultants
Frank J Cox Sales
Diaguide
Dominion Bridge-Sulzer
DSMA ATCON
K B Aerotech
R Laborie Associates
Micro Metallurgical
Non Destructive Testing Products
O'Donnell & Associates
Pullman Power Products of Canada
Qualitech Consultants
The S M Stoller
Tektrend International
United Electric Controls (Canada)
United Engineers & Constructors
Universal Pipe Line Enterprises
W C Investments
Wyle Laboratories

R

Radiation Counters
Allan Crawford Associates
Alphanuclear
Aptec Engineering
Baird
• Dosimeter
Eberline Instruments
EDA Instruments
EG & G Instruments
EG & G ORTEC
Helgeson Nuclear Services
Isotopen-Technik Dr Sauerwein GmbH
• Labserco
• LND
Ludlum Measurements
McPhar Instruments
Non Destructive Testing Products
Nuclear Measurements
Nuclear Supply
The Nucleus
Pylon Electronic Development Company
• Radionics Scientific
• Reuter-Stokes Canada
Rich Seifert & Company
Scintrex
Technical Marketing Associates
• Tennelec

Radiation counting systems
Allan Crawford Associates
Alphanuclear
Aptec Engineering
Baird
D S Davidson Company
• Dosimeter
Eberline Instruments
EG & G Instruments
EG & G ORTEC
Helgeson Nuclear Services
IRT
Isotopen-Technik Dr Sauerwein GmbH
Ludlum Measurements
Nuclear Measurements
The Nucleus
Panasonic Industrial
• Radionics Scientific
Reuter-Stokes Canada
Rich Seifert & Company
Scintrex
Technical Marketing Associates
• Tennelec

Radiation detector shields
Aptec Engineering
• Dosimeter
EG & G ORTEC
Gravatom Industries
Helgeson Nuclear Services
The Nucleus
Numet Engineering
Reactor Experiments
Rich Seifert & Company
Technical Marketing Associates
• Tennelec

Radiation detectors
see Detectors, Radiation

Radiation, health analysis
see Consultants, Radiation and Health

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Design, Supply, Development and Testing

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- AUTOMATED CONTROL
- IN VAULT EQUIPMENT
- SPECIAL TOOLING

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Flanders Filters
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Ionex Research
IRT
• Labserco
Mott Metallurgical
Nuclear Assurance
Nuclear Packaging
Nuclear Technology (NUTEK)
Numet Engineering
• Radionics Scientific
• Remote Technology
S & G Enterprises
Sinclair Macdonald Products
Stein Industrie
Suntral Services
• Tennelec
Trecan

Radiochemicals
American Nuclear Products
Amersham

Radioisotopes
American Nuclear Products
Amersham
• Atomic Energy of Canada — Radiochemical
McMaster University
Non Destructive Testing Products
Nuclear Science Center
The Nucleus
Technical Marketing Associates
University of Manitoba-Cyclotron Lab

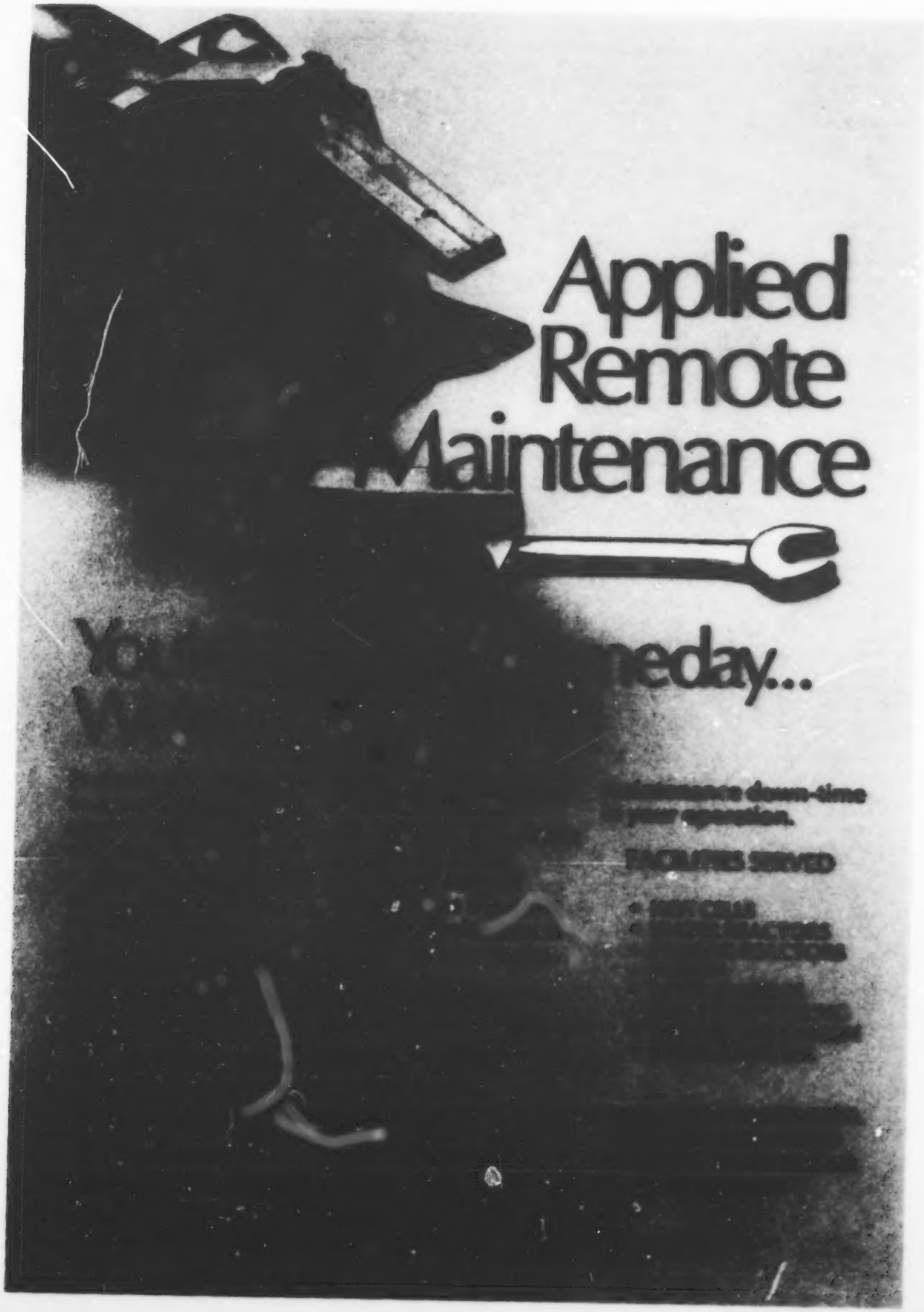
Radioisotope tracing services
• Atomic Energy of Canada — Radiochemical
Controls for Environmental Pollution

Radiopharmaceuticals
Amersham
University of Manitoba — Cyclotron Lab

Reactor instrument systems
see Instrumentation, Specialized

Reactor safety analysis
see Safety Analysis, Reactor

Reactors, power
• Atomic Energy of Canada — Candu Operations
Dominion Bridge-Sulzer
• Versatile Vickers


Applied
Remote
Maintenance

Reactors, research
- Atomic Energy of Canada — Research
- Canatom

Refuelling equipment, reactor
- Atcon Services
- Canadian General Electric
  GCA
  Hitachi (Canadian)
  Lefebvre Freres
- Remote Technology
  Standard Modern Technologies

Reprocessing, fuel elements
- Remote Technology

Research & Development
  Alphanuclear
- Atomic Energy of Canada — Research
  ASW Controls & Instruments
- Atcon Services
  Atlantic Research
- Babcock & Wilcox Canada
  Barringer Research
  Bristol Aerospace
- Canadian General Electric
  Canadian Mine Services
  Combustion Engineering-Super
  Controls for Environmental Pollution
  DSMA ATCON
  Eberline Instruments
  EG & G ORTEC
  Hawker Siddeley — Orenda
  Intertechnology
  IRT
  Micro Metallurgical
  Nuclear Science Center
  Numet Engineering
  Pylon Electronic Development Company
- Remote Technology
  S-Cubed
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  Serdula Systems
  Tektrend International
  University of Toronto
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  Wyle Laboratories

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- Canadian General Electric
  Cayuga Mfg
  Del Mar Avionics
  Fryston Associates Company
  GCA
  Hitachi (Canadian)
  Numet Engineering
- Remote Technology
  Spectrum Engineering
  Teleoperator Systems

S

Safety analysis, reactor
- Atomic Energy of Canada — Candu Operations
- Atomic Energy of Canada — Research
- Canatom
  DSMA ATCON
  James D Kendall Consultants
  MacLaren Plansearch
  Meikle Engineering
  O'Donnell & Associates
  Serdula Systems
  Spectrum Engineering
  The S M Stoller
  Tektrend International
  Utility Associates International
- W L Wardrop & Associates
- Westinghouse Canada

Scales, weighing, nuclear
  Anter
  Intertechnology

Scanners, isotope distribution
  EG & G ORTEC
  IRT
- Labserco

Seals, nuclear quality
  Alberox
  Byron Jackson Div Borg Warner (Canada)
  Crane Packing Company
  Durametallic Canada
  EG & G Sealol Canada
  The Presray
  Seal Master
  Technamould
  Thomson Gordon

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  Balteau Electric
  Esden
  Federal Laboratories
  The Mosler Safe
  MSE Engineering Systems
  Racon
  The S M Stoller
  Tracon Engineering
  Wackenhut of Canada
  W C Investments

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Sensors, radiation resistant
- Andec Mfg
  Beckman Instruments
  The Lewis Engineering
  Minco Products
  MSE Engineering Systems
  Pace Transducer
  Technical Marketing Associates
  Weed Instrument Company
  Willer Engineering

Shielding materials
  Aptec Engineering
  The Canada Metal Company
  Combustion Engineering-Super
  Corporation Outils Québec (Quebec Tools)
- Eldorado Resources
  Gravatom Industries
  Jarda Forgings & Castings Sales
  Non Destructive Testing Products
  The Nucleus
  Nuclear Shielding Supplies & Services of Canada
  Permali Canada
  The Presray
- Ralfor Steel
  Reactor Experiments
  Technical Marketing Associates

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  Euclid Garment Mfg
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  Nuclear Supply
  The Nucleus

Simulators, Training
  CAE Electronics

Siting analysis
  Canadian Mine Services
- Canatom
  DSMA ATCON
  MacLaren Engineers
  MacLaren Plansearch
  S-Cubed
  Senes Consultants
  United Engineers & Constructors
- W L Wardrop & Associates

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Sources, ion beam
  National Electrostatics

Sources, radioactive
  American Nuclear Products
- Atomic Energy of Canada — Radiochemical
- Dosimeter
  Eberline Instruments
  Non Destructive Testing Products
  The Nucleus
  Pylon Electronic Development Company
  Technical Marketing Associates
- Tennelec

Sources, radioisotopes
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Spent fuel baskets
- Canadian General Electric Combustion Engineering-Super
- Ecolaire Canada

GCA
Gitsch Canada
Hitachi (Canadian)
Lefebvre Freres
N O W & Associates

Spent fuel bay liners
- Ecolaire Canada

Horton CBI
- Ralfor Steel

TIW Industries

Spent fuel services
Nuclear Assurance
Utility Associates International

Spent fuel shipping containers
- Atcon Services

BB Howden
- Canadian General Electric Combustion Engineering-Super

Corporation Outils Quebec (Quebec Tools)
Dominion Bridge-Sulzer
- Ecolaire Canada
- Eldorado Resources

Gravatom Industries
Lefebvre Freres
Nuclear Assurance
Nuclear Packaging
Numet Engineering
- Ralfor Steel

Reade Mfg
Transnuclear
- Versatile Vickers

Start-up services
- Babcock & Wilcox Canada
- Canatom

CECO Consultants
- Consolidated Controls

Serdula Systems
United Engineers & Constructors

Steam generators, nuclear
- Babcock & Wilcox Canada
- Canadian General Electric Combustion Engineering-Super

Foster Wheeler
Hitachi (Canadian)
Stein Industrie

Steel plate, nuclear quality
Atlas Steels, Div. of Rio Algom
Dominion Bridge-Sulzer
Eastern Stainless Steel
Robert Mitchell
Newman Steel
Thyssen Marathon Canada
Uddeholm

Strainers, heavy water
Dominion Bridge-Sulzer
Numet Engineering
W C Investments

Strainers, nuclear quality
Associated Piping & Engineering
Diamond Canapower
Dominion Bridge-Sulzer
Numet Engineering
W C Investments

Stress analysis
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T

Tanks, active liquid waste
Combustion Engineering-Super
Dominion Bridge-Sulzer
- Ecolaire Canada

Foster Wheeler
Horton CBI
Robert Mitchell
Numet Engineering
- Ralfor Steel

TIW Industries
Tube Turns

Teletherapy machines
- Atomic Energy of Canada — Radiochemical

Television systems, nuclear application
Lennox Instruments
MSE Engineering Systems
Transduction

Thorium
Reactor Experiments

Training
see *Educational Services: Industry*
see *Simulators: Training*

Translation services, specialized, nuclear
- Atomic Energy of Canada — Candu Operations

Transport containers
see *Spent Fuel Shipping Containers*

ROBVON BACKING RINGS

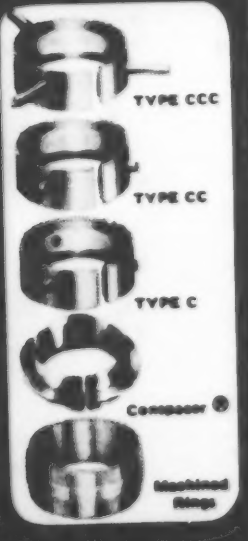
Design Originators Since 1943

Robvon Commercial Backing Rings are designed for quick, easy alignment of pipe or tubing and assure precise, close tolerance fit-up. They allow complete penetration and fusion of the weld and radiograph perfect certified welds. The patented NUBS automatically set the weld gap for the root-pass. Internal bevels and flat inner lands assure non-restricted fluid flow. Robvon Backing Rings are available in Carbon Steel, Chrome Alloys, Stainless Steel, Aluminum, Nickel, Cupro Nickel, and other exotic materials.

SPECIALTY ITEMS

Machined Rings to Customer Specifications. Test Plates, available in all weldable ferrous and non-ferrous materials. Weld Test Coupons for welder qualifications.

Consumable Insert Rings



ROBVON

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Transportation, radioactive materials
- Atcon Services
- D & D Disposal Services
- Gravatom Industries
- Nuclear Assurance
- Numet Engineering
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- Dominion Bridge-Sulzer
- Glitsch Canada
- Horton CBI
- Lefebvre Frères
- Union Carbide

Treatment systems, off-gas
- Engelhard Industries of Canada
- Flanders Filters
- Numet Engineering

Tube fittings
- Aeroquip (Canada)
- Autoclave Engineers
- Avon Valve & Fitting Company
- Crawford Fittings (Canada)
- Hoke Controls
- Jarda Forgings & Castings Sales
- Parker-Hannifin (Canada)
- Raychem (Canada)
- Robvon Backing Ring
- Swepco Tube
- Vicom

Tubes, calandria
- Bata Engineering
- Bristol Aerospace
- Fahramet
- Sandvik CDA
- Westinghouse Canada

Tubes, pressure
- Chase Nuclear (Canada)
- Pacific Tube
- Sandvik CDA

Tubing, nuclear instrumentation
- Autoclave Engineers
- Canadian General Electric
- Jarda Forgings & Castings Sales
- Nor-Sand Metals
- Pacific Tube
- Parker-Hannifin (Canada)
- Raychem (Canada)
- Sandvik CDA

Tubing, zircaloy, reactor grade
- Bristol Aerospace
- Canadian General Electric
- Chase Nuclear (Canada)
- Sandvik CDA
- Vereinigte Deutsche Metallwerke Canada
- W C Investments
- Westinghouse Canada

Turbine generators, nuclear
- BB Howden
- Canadian General Electric
- NEI Parsons
- Westinghouse Canada

U

Uranium, conversion services
- Eldorado Resources

Uranium, depleted products
- Eldorado Resources
- Leico Industries
- Reactor Experiments

Uranium, exploration
- Atkins Mining Consultants
- Canadian Mine Services
- Denison Mines
- EDA Instruments
- Esso Minerals
- Exploranium/Geometrics
- Geomex Development
- IRT
- David S. Robertson & Associates
- Saskatchewan Mining Development
- Scintrex
- Société de développement de la Baie James
- Uranerz Exploration & Mining
- Westfield Minerals

Uranium, marketing services
- Atkins Mining Consultants
- NUEXCO
- Saskatchewan Mining Development
- Uranerz Exploration & Mining

Uranium ore concentrates
- Amok
- Denison Mines
- Eldorado Resources
- Rio Algom
- Saskatchewan Mining Development
- Uranerz Exploration & Mining

Urinalysis
- Controls for Environmental Pollution
- Eberline Instruments
- Nuclear Activation Services
- Suntral Services

V

Valves, nuclear quality
- Anchor/Darling Valve
- Anderson, Greenwood
- Ascoletric
- Autoclave Engineers
- Avon Valve & Fitting Company
- BB Howden
- BIF
- Byron Jackson
- Canadian Worcester Controls
- Crane Canada
- Crawford Fittings (Canada)
- Diamond Canapower
- Dresser Canada
- Durriron Canada
- EG & G Sealol Canada
- Farris Industries
- Hoke Controls
- Hopkinsons
- Jamesbury Canada
- Masonellan of Canada
- Newman Hattersley
- Ontor
- Rockwell International of Canada
- Sinclair Macdonald Products
- Stoke Services
- Sulzer Canada
- Taylor Forge Canada
- Tufline
- Valcor Engineering
- Velan
- Henry Vogt Machine

Vessels, pressure
- Ascoletic
- Autoclave Engineers
- Babcock & Wilcox Canada
- Chase Nuclear Canada
- Combustion Engineering-Super
- Dominion Bridge-Sulzer
- Ecolaire Canada
- Foster Wheeler
- Horton CBI
- Marine Industries
- Robert Mitchell
- N O W & Associates
- Numet Engineering
- Ralfor Steel
- Taylor Forge Canada
- TIW Industries
- Tube Turns
- Universal Pipe Line Enterprises
- Versatile Vickers

Vibration analysis
see Consultants: Vibration

W

Waste handling services
- Canadian Mine Services
- Canatom
- IRT
- London Nuclear
- Nuclear Technology (NUTEK)
- Numet Engineering
- Suntral Services

Waste management equipment
see Radioactive Waste Management Equipment

Welding, nuclear equipment
- Astro-Arc International
- Babcock & Wilcox Canada
- Bristol Aerospace
- Combustion Engineering-Super
- Corporation Outils Québec (Quebec Tools)
- Dominion Bridge-Sulzer
- Ecolaire Canada
- Foster Wheeler
- Inter-City Welding Supplies
- IRT
- Justram Equipment
- Lefebvre Frères
- Marine Industries
- Robert Mitchell
- N O W & Associates
- Numet Engineering
- Pullman Power Products of Canada
- Roto Weld
- Thyssen Marathon Canada
- Unibraze of Canada
- Universal Pipe Line Enterprises
- E H Wachs

Whole-body radioactivity monitors
- EG & G Instruments
- EG & G ORTEC
- Helgeson Nuclear Services
- Labserco

Windows, radiation shielding
- Gravatom Industries
- Hot Cell Services
- Reactor Experiments
- Schott Optical Glass

Z

Zircaloy
- Bristol Aerospace
- CEZUS
- Chase Nuclear (Canada)
- Teledyne Wah Chang Albany
- Verbik Metals
- Vereinigte Deutsche Metallwerke

Zirconium
- Bristol Aerospace
- CEZUS
- Chase Nuclear (Canada)
- GA Technologies/Torrey Pines
- Teledyne Wah Chang Albany
- Verbik Metals
- Vereinigte Deutsche Metallwerke

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Suppliers' Addresses and Representatives

A

Accusonic Div., Ferranti O.R.E., Inc., P.O. Box 709. Falmouth Heights Rd., Falmouth, MA 02541. Contact: Dan Dozier, 617-548-5800.

Acoustic Emission Technology Corp., 1812 J Tribute Rd., Sacramento, CA 95815. Canadian Representative: Canadian NDE Technology Ltd., 18 Canso Rd., Rexdale, Ont. M9W 4L8. Contact: S. de Walle, 416-243-3456.

Acres Consulting Services Ltd., 480 University Ave., Toronto, Ont. M5G 1V2. Contact: J.G. Warnock, 416-595-2000.

Acrita International Ltd., P.O. Box 507, Vineland, Ont. L0R 2C0. Contact: Don MacLeod, 416-562-4795.

Adanac Research Corp., 220 Pegasus Ave., Northvale, N.J. 07647. Contact: Dot Hampton, 416-281-3410/514-286-4007.

AE Autoclave of Canada Ltd., 4129 Harvester Rd., Burlington, Ont. L7L 5M3. Contact: Peter Byrne, 416-632-6961.

Aeroquip (Canada) Inc., 287 Bridgeland Ave., Toronto, Ont. M6A 1Z7. Contact: Ronald D. Stover, 416-781-5261.

Aimark, Travers Ltd., 1875 Leslie St., Willowdale, Ont. Contact: Ted Thring, 416-475-3660.

Alberox Corp., Industrial Park, New Bedford, Mass 02745. Canadian Representative: Repco Electronics Co. Ltd., 119 Labrosse Ave., Pointe Claire, P.Q. H9R 1A3. Contact: Joseph Levy, 514-694-1877.

Alexander & Associates, 30 Kings Inn Trail, Thornhill, Ont. L3T 1T7. Contact: F.F. Alexander.

Alexander Vacuum Research Inc., 278 Main St., Greenfield, Mass 01301. Contact: John Carson, 413-774-2267.

Alfa-Laval Ltd., 113 Park St. S., Peterborough, Ont. K9J 3R8. Contact: Hans Johansson, 705-745-5735.

Allan Crawford Associates Ltd., 6503 Northam Dr., Mississauga, Ont. L4V 1J2. Contact: Brian Flippance, 416-678-1500.

Alphanuclear, 6380 B Viscount Rd., Mississauga, Ont. L4V 1H3. Contact: V. Roze, 416-676-1364.

American Air Filter, P.O. Box 35260, Louisville, KY 40232. Canadian Representative: American Air Filter, 400 Stinson Blvd., Montreal, P.Q. H4N 2G1. Contact: Tom Rogers, 514-748-6931.

American Building Maintenance Industries, 333 Fell St., San Francisco, CA 94102. Canadian Representative: Associated Building Maintenance Co., 112 St. Clair St. W., Ste. 403, Toronto, Ont. M4V 2Y3. Contact: Jim Randfield, 416-967-1740.

• **American Nuclear Society,** 555 North Kensington Ave., La Grange Park, IL 60525. 312-352-6611.

American Nuclear Products Inc., 1232 E. Commercial, Springfield, MO 65803. Contact: Al Gordon, 417-869-4432.

Amersham Corp., 505 Iroquois Shore Rd., Oakville, Ont. L6H 2L3. Contact: Paul Couture, 416-842-2720.

Amok Ltd., 817-825 45th St. W., P.O. Box 9204, Saskatoon, Sask. S7K 3X5. Contact: Jean-Pierre Slama, 306-242-8894.

AMP of Canada Ltd., 20 Esna Park Dr., Markham, Ont. L3R 1E1. Contact: Al Shields, 416-475-6222.

Anchor/Darling Valve Co., 320 King of Prussia Rd., Radnor, PA 19087. Contact: R.E. Bergman, 215-687-9733.

• **ANDEC Mfg. Ltd.,** 18 Canso Rd., Rexdale, Ont. M9W 4L8. Contact: S. de Walle, 416-243-3456.

Anderson, Greenwood & Co., P.O. Box 1097, Bellaire, Texas 77081. Canadian Representative: Cantech Corp., 1916 27th Ave. N.E., Calgary, Alta T2E 7A5. Contact: D.A. Schmeeckle, 403-230-1581.

Anderson Metal Industries, 1101 Finch Ave. W., Downsview, Ont. M3J 2C9. Contact: N.J. Whitehead, 416-665-8463.

Anter Corporation, 1700 Universal Rd., Pittsburgh, PA 15235. Contact: P.S. Gaal.

Aptec Engineering Ltd., 4251 Steeles Ave. W., Downsview, Ont. Contact: P.B. Stark, 416-661-9722.

Armatek Controls Ltd., 27 Fima Cresc., Toronto, Ont. M8W 3R1. Contact: R. Sage, 416-251-3111.

Ascolectric Ltd., P.O. Box 160, 10 Airport Rd., Brantford, Ont. N3T 5M8. Contact: Dennis S. Hladysh, 519-756-5287.

Associated Building Maintenance Co., 112 St. Clair St. W., Ste. 403, Toronto, Ont. M4V 2Y3. Contact: Jim Randfield, 416-967-1740.

Associated Kellogg Ltd., 20 Eglinton Ave. W., Toronto, Ont. M4R 2E5. Contact: R. Brewer, 416-482-7700.

Associated Piping & Engineering Corp., Temp Flex Div., 1707 W. Compton Blvd., P.O. Box 4309, Compton, CA 90224. Canadian Representative: Cancoppas Ltd., P.O. Box 713, Oakville, Ont. L6J 5C1. Contact: John Coomey, 416-845-4841.

Associated Tube Industries Ltd., 7455 Woodbine Ave., Markham, Ont. L3R 1A7. Contact: G.D. McRae, 416-475-6464.

Astro-Arc International, 10941 La Tuna Cny Rd., Sun Valley, CA 91352. Canadian Representative: Export Tool & Welding Co. Ltd., 5 Brydon Dr., Rexdale, Ont. M9W 4M7. Contact: Lee Rrouse, 416-734-7100.

ASW Controls & Instruments Ltd., 3877 Chesswood Dr., Downsview, Ont. M3J 2R8. Contact: A. Weinberger, 416-630-5883.

• **Atcon Services Ltd.,** 4195 Dundas St. W., Toronto, Ont. M8X 1Y4. Contact: C. Corke, 416-239-3012 or 416-625-1204.

Atkins Mining Consultants, 1118 - 111 Richmond St. W., Toronto, Ont. M5H 2G4. Contact: W. Atkins, 416-368-7679.

Atkinson Steel Co., 6406-A North Lamar Blvd., Austin, Texas 78752. Contact: G.D. Atkinson, P.E.

Atlantic Research Corp., 5390 Cherokee Ave., Alexandria, VA 22314. Contact: Ellen Levin, 703-642-4216.

Atlas Alloys, Div. of Rio Algom Ltd., 161 The West Mall, Etobicoke, Ont. M9C 4V8. Contact: W.P. Giroux, 416-622-3100.

Atlas Steels, Div. of Rio Algom Ltd., Centre St., Welland, Ont. Contact: J.G. Brammall, 416-735-5661.

Atlas Testing Labs & Services (Oakville) Ltd., 389 Davis Rd., Oakville, Ont. L6J 2X2. Contact: Brian Munro, 416-845-9542.

• **Atomic Energy of Canada Ltd. — Candu Operations,** Sheridan Park Research Community, Mississauga, Ont. L5K 1B2. Contact: John A. Macpherson, 416-823-9040.

• **Atomic Energy of Canada Ltd. — Radiochemical Co.,** P.O. Box 6300, Ottawa, Ont., K2A 3W3. Contact: Ken Buckingham, 613-592-2790, Ext. 441.

• **Atomic Energy of Canada Ltd. — Research Co.,** Chalk River Nuclear Laboratories, Chalk River, Ont. K0J 1J0. Contact: Donna Newman (Commercial Operations), 613-583-3311, local 2820.

Autoclave Engineers Inc., 2930 West 22nd St., P.O. Box 4007, Erie, PA 16512. Canadian Representative: AE Autoclave of Canada Ltd., 4129 Harvester Rd., Burlington, Ont. L7L 5M3. Contact: Peter Byrne, 416-632-6961.

Automatec, Div. of BG CHECO International Ltd., 7700 de Lamartine, Ville d'Anjou, P.Q. H1J 2A8. Contact: Jacques Le Bel.

Aviation Electric Ltd., P.O. Box 2140, St. Laurent, P.Q. H4L 4X8. Contact: Brendon Korneski, 514-744-2811.

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Avon Valve & Fitting Co. Ltd., 705 Progress Ave., Unit 58, Scarborough, Ont. M1H 2X1. Contact: Bruce MacCorkindale, 416-438-1233.

B

• **Babcock & Wilcox Canada.,** Coronation Blvd., Cambridge, Ont. N1R 5V3. Contact: S. Stultz or T. Griffith, 519-621-2130.

Bailey Controls, 860 Harrington Court, Burlington, Ont. L7N 3N4. Contact: E.P. Smith.

Baird Corp., 125 Middlesex Turnpike, Bedford. MA 01730. Contact: Ken J. Babeaux, 617-276-6205.

Balteau Electric Corp., 63 Jefferson St., Stamford, CT 06902. Contact: Tony Ruiz, 203-324-6118.

Barringer Research Ltd., 304 Carlingview Dr., Rexdale, Ont. M9W 5G2. Contact: Clayton Babcock, 416-675-3870.

• **Bata Engineering, Div. of Bata Industries Ltd.,** Batawa, Ont., K0K 1E0. Contact: Cam Nardocchio, 613-398-6106.

BB Howden, 1510 Birchmount Rd., Scarborough, Ont. M1P 2G6. Contact: W.C. Higgins, 416-752-7310.

B.C. Instruments Inc., P.O. Box 430, Proctor Rd., Schomberg, Ont. L0G 1T0. Contact: H.P. Patel, 416-366-6007.

Bechtel Canada Ltd., 250 Bloor St. E., Toronto, Ont. M4W 3K5. Contact: R.P. Ehrlich, 416-928-1600.

Beckman Instruments Inc., 89 Commerce Rd., Cedar Grove, N.J. 07009. Canadian Representative: Beckman Instruments Inc., 901 Oxford Street, Toronto, Ont. M8Z 5T2. Contact: Len Carter, 416-251-5251.

Bergen-Paterson Pipe-Support Corp., 74 Commerce Way, Woburn, MA 01888. Canadian Representative: Carpenter & Paterson Pipe Hangers Ltd., P.O. Box 606, Jarvis, Ont. N0A 1J0. Contact: R.J. Roberts, 519-587-2571.

Berkeley Nucleonics, 1198 Tenth St., Berkeley, CA 94710. Contact: John Yee, 415-527-1121.

BIF Div. of General Signal Ltd., 2505 Dunwith Dr., Unit 6, Mississauga, Ont. L5L 1R9. Contact: Jack Hymby, 416-828-7355.

Bingham-Willamette Ltd., 4129 Lozells Ave., Burnaby, B.C. V5A 2Z5. Contact: W.A. Wilby, 604-420-5330.

Birns Nuclear Lighting, Div. of Birns Oceanographics Inc., P.O. Box 24160, Los Angeles, CA 90024. Canadian Representative: Offshore Marketing, 1798 Granville St., Halifax, N.S. B3J 1X7. Contact: David Lyons, 902-429-2205.

Blenkhorn and Sawle Ltd., 100 Grantham Ave., St Catharines, Ont. L2R 7B9. Contact: P.M. Dobrocky, 416-684-9251.

Boston Insulated Wire & Cable Co. Ltd., 118 Shaw St., Hamilton, Ont. L8L 7V3. Contact: Ed Ladesic, 416-529-7151.

Brewer Engineering Laboratories Inc., 513 Mill St., P.O. Box 288, Marion, Mass. 02738. Contact: LaVerne F. Wallace, 617-748-0103. Canadian Representative: Alexander D. Smart Ltd., 351 Steelcase Rd. W., Unit 3, Markham, Ont. L3R 4H9.

Bristol Aerospace Ltd., P.O. Box 874, Winnipeg, Man. R3C 2S4. Contact: J.K. Corrie, 204-775-8331.

Brooks Instrument Div., P.O. Box 150, Markham, Ont. L3P 3J6. Contact: George Low.

Brown Boveri Canada Inc., 2260 Place du Canada, Montréal, P.Q. H3B 2N2. Contact: Catherine Dunlop.

The George Brown College of Applied Arts & Technology, P.O. Box 1015, Station B., Toronto, Ont. M5T 2T9. Contact: Dr. M.K. Straka, 416-967-1212, Ext. 3278.

Burndy Inc., 1530 Birchmount Rd., Scarborough, Ont. M1P 2G9. Contact: Ross Davies, 416-757-8761.

Byron Jackson, Div. Borg-Warner (Canada) Ltd., P.O. Box 180, Station H, Toronto, Ont. M4C 5J1. Contact: J.E. Spencer, 416-757-6241.

C

CAE Electronics Ltd., P.O. Box 1800, St. Laurent, P.Q. H4L 4X4. Contact: R.F. Kemerer, 514-341-6780.

Canada Alloy Castings, Ltd., 529 Manitou Dr., Kitchener, Ont. N2C 1S2. Contact: J.A. Hartnell, 519-893-1161.

• **Canada Forgings,** Div. of Toromont Industries, P.O. Box 308, Welland, Ont. L3B 5P8. Contact: M.E. Fraser, 416-735-1220.

The Canada Metal Co. Ltd., 721 Eastern Ave., Toronto, Ont. M4M 1E6. Contact: D. Linton, 416-465-4684.

Canadian Astronautics Ltd., 1024 Morrison Dr., Ottawa, Ont. K2H 8K7. Contact: John Amyot, 613-820-8280.

• **Canadian General Electric Co. Ltd.,** 107 Park St. N., Peterborough, Ont. K9J 7B5. Contact: C. Wilson, 705-748-7181.

• **Canadian Institute for Radiation Safety (CAIRS),** Box 460, Elliot Lake, Ont. P5A 2J9. Contact: Roger Harris, 613-235-0280.

Canadian Mine Services Ltd., 1595 Clark Blvd., Brampton, Ont. L6T 4C1. Contact: P.R. White, 416-792-2700.

Canadian NDE Technology Ltd., 18 Canso Rd., Rexdale, Ont. M9W 4L8. Contact: Allen T. Green, 416-243-3456.

• **Canadian Standards Association,** 178 Rexdale Blvd., Rexdale, Ont. M9W 1R3, 416-744-4124.

Canadian Worcester Controls, 20 Mid-Dominion Acres, Scarborough, Ont. M1S 4A5. Contact: Hannes M. Mueller, 416-298-1671.

• **Canatom Inc.,** 740 Notre-Dame St. W., Montreal, P.Q. H3C 3X6. Contact: L.A. Phillips, 514-879-4848.

Cancoppas Ltd., 1031 N. Service Rd. E., Oakville, Ont. L6H 1A6. Contact: John Coomey, 416-845-4841.

Cantech Corp., 1916 27th Ave. N.E., Calgary, Alta. T2E 7A5. Contact: D.A. Schmeeckle, 403-230-1581.

Capitol Pipe & Steel Products, 7650 Bath Rd., Mississauga, Ont. L4T 1L2. Contact: Rick Grabowski.

Cardinal Industrial Products Corp., 3873 West Oquendo Rd., Las Vegas, NV 89118. Contact: John J. Simko.

Carpenter & Paterson Pipe Hangers Ltd., P.O. Box 606, Jarvis, Ont. N0A 1J0. Contact: R.J. Roberts, 519-587-2571.

Cayuga Mfg. Corp., 4979 Lake Ave., Buffalo, N.Y. 14219. Contact: B.E. Long, 716-823-5600.

CECO Consultants Ltd., 2300 Yonge St., Toronto, Ont. M4P 2W6. Contact: Dr. G.A. Nicholson, 416-482-8500.

Cegelec Canada Inc., 1400 Blvd. Industriel, Laprairie, P.Q. J5R 2E5. Contact: Pierre Pouderoux, 514-946-9693.

Ceramaseal, P.O. Box 25, New Lebanon Center, N.Y. 12126, Canadian Representative: D.T. Shaw Co. Ltd., 515 Deslauriers St., Montreal, P.Q. H4N 1W2. Contact: Gerry Walker or Graham Shaw, 514-332-1163.

CEZUS, 15, rue du Rocher, 75361 Paris, Cedex 08, France. Canadian Representative: Intsel of Canada Ltd., 5185 General Rd., Mississauga, Ont. L4W 2K4. Contact: John A. Robinson, 416-625-8103.

Chase Nuclear (Canada) Ltd., P.O. Box 7, 460 McCartney St., Arnprior, Ont. K7S 3H4. Contact: D.M. Toole, 613-623-6544.

• **Chromalox Canada,** 210 Rexdale Blvd., Rexdale, Ont. M9W 2R4. Contact: Rick Vyrostko, 416-743-8000.

CHT Steel Co., 300 Newkirk Rd., Richmond Hill, Ont. L4C 4Y8. Contact: J. Martin Gill, 416-884-5000.

College Tool & Die Ltd., 3845 Nashua Dr., Mississauga, Ont. L4V 1R3. Contact: Roman Kuczynski, 416-677-5130.

Combustion Engineering-Super Ltd., 99 Bank St., Ottawa, Ont. K1P 6C5. Contact: J. Skinner, 613-560-4741.

• **Consolidated Controls Corporation,** 15 Durant Ave., Betnel, CT 06801. Contact: Ronald S. Pickman, 203-796-6245.

Control Data Canada Ltd., 1855 Minnesota Crt., Mississauga, Ont. L5N 1K7. Contact: Holle Watts, 416-826-8640.

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Controls for Environmental Pollution, Inc., 1925 Rosina St., P.O. Box 5351, Santa Fe, NM 87502. Contact: James Mueller, 505-982-9841.

Cooperheat of Canada Ltd., 1746 Slough St., Mississauga, Ont. L4T 1G3. Contact: Anthony J. Smith, 416-677-7546.

Corporation Outils Québec, 55 Benjamin Hudon, St. Laurent, P.Q. Contact: Serge St-Hilaire, 514-331-7720.

Frank J. Cox Sales Ltd., 66 Chauncey Ave., Toronto, Ont. M8Z 2Z4. Contact: H. Cox.

Crane Canada Inc., 5800 Côte de Liesse Rd., Montréal, P.Q. H4T 1B4. Contact: S. Whittaker, 514-735-3592.

Crane Packing Co. Ltd., 423 Green Rd., Stoney Creek, Ont. Box 3248, Station C, Hamilton, Ont. L8H 7L3. Contact: John Putnins, 416-662-6191.

Crawford Fittings (Canada) Ltd., P.O. Box 36, 4605 Kent Ave., Niagara Falls, Ont. L2E 6S8. Contact: H.B. Erends, 416-356-2255.

Cusco Industries Inc., 393 Deslauriers, Montreal, P.Q. H4N 1W3. Contact: Paul Mardinian, 514-334-1540.

D

D & D Disposal Services Ltd., P.O. Box 372, Smithville, Ont. L0R 2A0. Contact: Bryan Maskell, 416-957-3323.

DAF Indal Ltd., 3570 Hawkestone Rd., Mississauga, Ont. L5C 2V8. Contact: Frank Davenport, 416-275-5300.

D.S. Davidson Co. Inc., 19 Bernhard Rd., North Haven, CT 06473. Canadian Representative: EG&G Instruments, Div. EG&G Canada Ltd., 436 Limestone Cresc., Downsview, Ont. M3J 2S4. Contact: Emery Danko, 416-663-6230.

Davis Controls Ltd., P.O. Box 160, Islington, Ont. M9A 4X2. Contact: Paul Grenfell, 416-233-3211.

Del Mar Avionics, 1601 Alton Ave., Irvine, CA 92714. Canadian Representative: Rotator Products, 455 McNeil Ave., Willowdale, Ont. M2H 2C9. Contact: Tony Smith, 416-491-7843.

Denison Mines Ltd., P.O. Box 40, Royal Bank Plaza, Toronto, Ont. M5J 2K2. Contact: Noel O.Brien, 416-865-1991.

Diaguide Incorporated, 35 Ramland Road, Orangeburg, NY 10962. Canadian Representative: R. Laborie Associates, 48 Galaxy Blvd., Unit 412, Rexdale, Ont. M9W 4Y5. Contact: Ed Kornachuk, 416-675-5848.

Diamond Canapower, P.O. Box 5051, 1122 Pioneer Rd., Burlington, Ont. L7R 4A7. Contact: G.T.B. Clark, 416-335-0321.

Digidyne, Inc., 785 Ave. Lajoie, Dorval, P.Q. H9P 1G7. Contact: Nick Horne, 514-631-1891.

Dikkers Valves of Canada Ltd., 271 Glidden Rd., Brampton, Ont. L6W 1H9. Contact: Earl M. Schofield, 416-457-9677.

Dominion Bridge-Sulzer Inc., 555 Notre-Dame St., Lachine, P.Q. H8S 2B1. Contact: C. Doyon, 514-634-3551.

Doniee Nuclear, 9 Fenmar Dr., Weston, Ont. M9L 1L5. Contact: W.H. Bulger, 416-743-4410.

• **Dosimeter Corp.,** 11286 Grooms Rd., Cincinnati, Ohio 45242. Contact: Al Zirkes, 513-489-8100.

Dresser Canada Inc., 6688 Kitimat Rd., Mississauga, Ont. L5N 1P8. Contact: E.W. Anekenman, 416-826-8411, ext. 215.

DSMA ATCON Ltd., 4195 Dundas St. W., Toronto, Ont. M8X 1Y4. Contact: V. Smiltnieks, 416-239-3012.

Durafab Inc., Box 658, Cleburne Texas 76031. Canadian Representative: Safety Supply Canada, 214 King St. E., Toronto, Ont. M5A 1J8. Contact: Ken Hilder, 416-364-3234.

Durametallic Canada Inc., 130 Edward St., St. Thomas, Ont. N5P 1Z1. Contact: David M. Lloyd, 519-631-9946.

Duriron Canada Inc., 430 Signet Dr., Weston, Ont. M9L 2T6. Contact: A. Wasylenko, 416-749-6633.

Durmitor Inc., 960 Alness St., Units 23 & 24, Downsview, Ont. M3J 2S1. Contact: B. Veljkovic, 416-663-2313.

E

Eastern Electric, 5775 Ferrier St., Montreal, P.Q. H4T 1N3. Contact: Roy Tonks, 514-733-9961.

Eastern Stainless Steel Co., P.O. Box 1975, Baltimore, MD 21203. Contact: B.F. Pritchard.

Eberline Instrument Corp., P.O. Box 2108, Sante Fe, New Mexico. Canadian Representative: Safety Supply Canada, 214 King St. E., Toronto, Ont. M5A 1J8. Contact: Grant Moar, 416-364-3234.

• **Ecolaire Canada Ltd.,** 41 Ardelt Place, Kitchener, Ont. N2C 2C8. Contact: J.E. Templeton, 519-745-7307.

EDA Instruments Inc., 1 Thorncliffe Park Dr., Toronto, Ont. M4H 1G9. Contact: Sandra C. Kirby, 416-425-7800.

EG & G Instruments, Div. EG&G Canada Ltd., 436 Limestone Cresc., Downsview, Ont. M3J 2S4. Contact: E.A. Danko, 416-663-6230.

EG & G ORTEC, 100 Midland Rd., Oak Ridge, TN 37830. Canadian Representative: EG&G Instruments, 436 Limestone Cresc., Downsview, Ont. M3J 2S4. Contact: E.A. Danko, 416-663-6230.

EG & G Sealol Canada, 1601 Trans Canada Hwy, Dorval, P.Q. H9P 1J1. Contact: R.L. Page.

• **Eldorado Resources Ltd.,** 400 - 255 Albert St., Ottawa, Ont. K1P 6A9. Contact: G.W. Fox, 613-238-5222.

Electrolab Ltd., P.O. Box 320, Belleville, Ont. Contact: Norman Wilson, 613-962-9577.

Endress & Hauser, Inc., 2350 Endress Place, P.O. Box 246-1, Greenwood, IN 46142. Canadian Representative: Davis Controls Ltd., P.O. Box 160, Islington, Ont. M9A 4X2. Contact: Paul Grenfell, 416-233-3211.

Enercorp Instruments Ltd., P.O. Box 20, Station U, Toronto, Ont. M8Z 5M4. Contact: V. McNally, 416- 231-5335.

Engelhard Industries of Canada Ltd., 100 Engelhard Dr., P.O. Box 340, Aurora, Ont. L4G 3N1. Contact: Betty-Anne Maynard, 416-727-3191.

Erico Inc., 46 Ingram Dr., Toronto, Ont. M6M 2L6. Contact: I.W. Stewart, 416-249-3363.

Esden Ltd., 1967 Leslie St., Don Mills, Ont. M3B 2M3. Contact: W.H. Edwards, 416-441-4100.

Esso Minerals Canada, Esso Plaza, 237 Fourth Ave. S.W., Calgary, Alta. Contact: D.O. Downing, 403-267-1050.

Euclid Garment Mfg. Co., 333 Martinel Dr., P.O. Box 535, Kent, Ohio 44240. Contact: Edward B. Davis, 216-673-7413.

Exploranium/Geometrics, 436 Limestone Cresc., Downsview, Ont. M3J 2S4. Contact: John Garland, 416-661-1966.

Export Tool & Welding Co. Ltd., 5 Brydon Dr., Rexdale, Ont. M9W 4M7. Contact: Lee Rrouse, 416-743-7100.

Extech Ltd., 1638 West Sixth Ave., Vancouver, B.C. V6J 1R3. Contact: Murray Ward.

• **Ezeflow,** 300 Canal Bank, Ville St. Pierre, P.Q. H8R 1H3. Contact: J.M. Latendresse, 514-364-1741.

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Fahramet, Div. of Indusmin Ltd., P.O. Box 1700, Orillia, Ont., L3V 6L6. Contact: Larry M. LePage, 705-325-2781.

Farr Co. Ltd., 2785 Francis Hughes Ave., Chomeday, Laval, P.Q. H7L 3J6. Contact: J.M. Doyle, 514-384-6401.

Farris Industries Canada, Shaver St. at Hwy. 2, P.O. Box 1210, Brantford, Ont. N3T 5T3. Contact: S.G. DiTomasso, 519-756-4800.

Federal Laboratories Inc., Saltsburg, PA 15681. Contact: D. Cunningham, 412-639-3511. Canadian Representative: R. Nicholls Dist. Inc., 372 Ste-Catherine W., Ste. 410, Montreal, P.Q. H3B 1A2. 514-861-3391.

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Galveston Houston Company Ltd., 5638 88th St., Bay #3, Edmonton, Alta. T6E 5R8. Contact: Gilles Landry, 403-465-5251.

Gamma-Metrics, P.O. Box 178524, San Diego, CA 92117 - 0952. Contact: Richard L. Conwell, 619-292-6168.

GCA Corp. — Par Systems, 3460 Lexington Ave. N., St. Paul, MN 55112. Contact: Raymond S. Karinen, 612-484-7261.

Gellman, Hayward & Partners Ltd., 27 Queen St. E., Toronto, Ont. M5C 2M6. Contact: Thomas Stark, 416-862-0430.

General Eastern Instruments Corp., 50 Hunt St., Watertown, MA 02172. Canadian Representative: ASW Controls & Instruments, 3877 Chesswood Dr., Downsview, Ont. M3J 2R8. Contact: Alex Weinberger, 416-630-5883.

Genge-Seed Equip. Ltd., 21 Bradwick Dr., Unit 1A, Concord, Ont. L4K 1B1. Contact: Bruce Seed, 416-665-0555.

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Industrial Training Corp., 14616 Southlawn Lane, Rockville, MD 20853. Canadian Representative: Electrolab Ltd., P.O. Box 320, Belleville, Ont. Contact: Norman Wilson, 613-962-9577.

Ingersoll Rand Canada Inc., 560 Conestoga Blvd., Cambridge, Ont. Contact: Greg Ast, 519-621-4020.

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Isotopen-Technik Dr. Sauerwein GmbH, Bergische Strabe 16, 5657 Haan/ Rheinl, West Germany. Canadian Representative: Canadian NDE Technology Ltd., 18 Canso Rd., Rexdale, Ont. M9W 4L8. Contact: S. de Walle, 416-243-3456.

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K.B. Aerotech, P.O. Box 350, Lewiston, PA 17044. Canadian Representative: Canadian NDE Technology Ltd., 18 Canso Rd., Rexdale, Ont. M9W 4L8. Contact: S. de Walle, 416-243-3456.

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Nuclear Technology Corp., (NUTEK), P.O. Box 1, Arnston, CT 06231. Contact: Thomas F. D'Muhala, 203-537-2387.

The Nucleus Inc., P.O. Box 2561, 761 Emory Valley Rd., Oak Ridge, Tenn 37830. Canadian Representative: Merlin Scientific Ltd., 247 Armstrong Ave., Unit 6, Georgetown, Ont. L7G 4X6. Contact: David Whiting, 416-877-0171.

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David S. Robertson & Associates, 145 King St. W., 24th fl., Toronto, Ont. M5H 1V8. Contact: D.S. Robertson, 416- 366-1921.

• **Robvon Backing Ring Co.,** 365 Blair Rd., P.O. Box 277, Avenel, NJ 07001. Canadian Representative: Osmond Agencies (1971) Ltd., P.O. Box 60, D.D.O. Post Office, Dollard Des Ormeaux, P.Q. H9G 2H5. Contact: Edward Cullen, 514-695-7231.

Rochester Instrument Systems Ltd., 915 Kipling Ave., Toronto, Ont. M8Z 5H4. Contact: P.A. Dowdle, 416-233-6218.

Rockwell International of Canada Ltd., 2345 Stanfield Rd., Mississauga, Ont. L4Y 3Y3. Contact: R. Hatton, 416-275-1694.

Rosemount Instruments Ltd., 1885 Meyerside Dr., Mississauga, Ont. L5T 1G7. Contact: H.A. Rasanen, 416- 678-1000.

Rotator Products, 455 McNeil Ave., Willowdale, Ont. M2H 2C9. Contact: Tony Smith, 416-491-7843.

Roto Weld Ltd., 5035 Timberlea Blvd., Units 1-2-3, Mississauga, Ont. L4W 2W9. Contact: Robert Bennett, 416-624-4877.

S

Safety Corporation of America, 26 West Harris St., Savannah, GA 31401. Canadian Representative: Dennis Ford, 1235 Second St., Beaver, PA 15009.

Safety Supply Canada, 214 King St. E., Toronto, Ont. M5A 1J8. Contact: Ken Hilder, 416-364-3234.

Sandvik Canada Corp., 6835 Century Ave., Mississauga, Ont. L5N 2L2. Contact: Ken Ayres, 416-826-8900.

Sargent Industries/Central Research Laboratories Div., P.O. Box 75, Red Wing, MN 55066. Contact: D. James Hindle.

Saskatchewan Mining Development Corp., 122 - 3rd Ave. N., Saskatoon, Sask. S7K 2H6. Contact: Rita Mirwald, 306-664-7005.

Scarborough & Grant Co. Ltd., 30 LePage Crt., Downsview, Ont. M3J 1Z9. Contact: Bruce Jones, 416-633-4130.

Schott Optical Glass Inc., 400 York Ave., Duryea, PA 18642. Contact: Heinz Hoffmann, 717-457-7485.

Scintrex Ltd., 222 Snidercroft Rd., Concord, Ont. L4K 1B5. Contact: Gerald Stork, 416-669-2280.

S-Cubed (formerly Systems, Science & Software), P.O. Box 1620, La Jolla, CA 92038. Canadian Representative: Extech Ltd., 1638 W. Sixth Ave., Vancouver, B.C. V6J 1R3. Contact: Murray Ward.

Seal Master Corp., P.O. Box 145, Kent, OH 44240. Contact: Edward Bittle.

Sedgwick Alexander Inc., P.O. Box 154, Royal Bank Plaza, Toronto, Ont. M5J 2J4. Contact: W.J. Lucas, 416-865-1000.

Seneca College of Applied Arts & Technology, 1750 Finch Ave. E., Toronto, Ont. M2J 2X5. Contact: The Registrar, 416-491-5050, ext. 227.

Senes Consultants Ltd., 499 McNicoll Ave., Willowdale, Ont. M2H 2C9. Contact: Dr. D.M. Gorber, 416-499-5030.

Serdula Systems Ltd., Glendale Plaza, P.O. Box 1808, Deep River, Ont. K0J 1P0. Contact: Kenneth Serdula, 613-584-4588.

S & G Enterprises Inc., 5626 N. 91st St., Milwaukee, WI 53225. Contact: L.C. Griffith, 414-464-5310.

D.T. Shaw Co. Ltd., 515 Deslauriers St., Montreal, P.Q. H4N 1W2. Contact: Gerry Walker or Graham Shaw, 514-794-7800.

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Sherex Industries Ltd., 4180 Morris Dr., Unit 6, Burlington, Ont. L7L 5L6. Contact: Joe Scherer, 416-639-7701.

• **Shi Pumps Ltd.,** P.O. Box 728, Guelph, Ont. N1H 6L8. Contact: J. Baker, 519- 824-4600.

Sinclair Macdonald Products Ltd., 112 Doncaster Ave., Thornhill, Ont. L3T 1L3. Contact: Sinclair Macdonald, 416-889-8511.

S & J Engineering Inc., 32 Gifford St., Toronto, Ont. M5A 3J1. Contact: David F. James, 416-960-0778.

Alexander D. Smart Ltd., 351 Steelcase Rd. W., Unit 3, Markham, Ont. L3R 4H9.

Société de développement de la Baie James, 800 Blvd. Maisonneuve E., Montreal, P.Q. H2L 4M6. Contact: Gilles M. Dionne, 514-284-0270.

Spar Aerospace Ltd., RMS Div., 1700 Ormont Dr., Weston, Ont. M9L 2W7. Contact: Dr. C. Wagner-Bartak, 416-745-9680.

Spectrum Engineering Corporation Ltd., P.O. Box 687, Peterborough, Ont. K9J 7A5. Contact: M.B. Struthers, 705-743-7520.

P.J. Spratt & Associates, 160 Perth Ave., Toronto, Ont. M6P 3X5. Contact: Denny Peirce, 416-536-8210.

SRDC Inc., 130 Adelaide St. W., Ste. 1818, Toronto, Ont. M5H 3P5. Contact: R. Winton, 416-362-1993.

S & S X-Ray Products Inc., 87-93 Jay St., Brooklyn, NY 11201. Canadian Representative: Canadian NDE Technology Ltd., 18 Canso Rd., Rexdale, Ont. M9W 4L8. Contact: S. de Walle, 416-243-3456.

Standard-Modern Technologies, 69 Montcalm Ave., Toronto, Ont. M6E 4N9. Contact: R. Lonsdale, 416-787-2494.

Standard Steel, Walnut St., Burnham, PA 17009. Canadian Representative: Canada Forgings, Div. of Toromont Industries, Welland, Ont. L3B 5P8. Contact: Jim Fraser, 416-735-1220.

Stauff Corp., 21-23 Industrial Park, Waldwick, NJ 07463. Contact: Manfred Reige, 201-444-7800. Canadian Representative: Hyseco Fluid Systems, 145 W 2nd Ave., Vancouver, B.C., 604-879-8877.

Steerne Catalytic Ltd., 805 N. Christina St., P.O. Box 3-08, Sarnia, Ont. N7T 7M7. Contact: Wayne Simpson, 519-336-4400.

Stein Industrie, 19-21 Ave. Morane-Saulnier, 78140 Velizy Villacoublay, France. Canadian Representative: Cegelec Canada Inc., 1400 Blvd. Industriel, Laprairie, P.Q. J5R 2E5. Contact: Pierre Pouderoux, 514-946-9693.

The S.M. Stoller Corp., 1250 Broadway, New York, NY 10001. Contact: C.P. Aiello, 212-868-2800.

Stork Services BV, P.O. Box 2013, 7550 CA Hengelo (o), The Netherlands. Canadian Representative: Dikkers Valves of Canada Ltd., 271 Glidden Rd., Brampton, Ont. L6W 1H9. Contact: Earl M. Schofield, 416-457-9677.

Strite Industries Ltd., 298 Shepherd Ave., Cambridge, Ont. N3C 1V1. Contact: Wm. From, 419-658-9361.

Sulzer Canada Inc., 60 Bloor St. W., Ste. 700, Toronto, Ont. M4W 3B8. Contact: David Murdoch, 416-923-2034.

Sumtrol Services Inc., P.O. Box 57722, Webster, Tx 77598. Contact: C.E. Winters Jr., 713-334-2346.

Suprenc Inc., 1050 St. Amour St., Montreal, P.Q. H4S 1J2. Contact: Hugh Palmer, 514-636-8423.

Sutherland-Schultz Ltd., 859 Courtland Ave. E., Kitchener, Ont. N2G 4H5. Contact: James Dawdy, 519-743-4123.

Swepco Tube Corp., 1 Clifton Blvd., Clifton, NJ. Contact: Andrew Curland, 201-778-3000.

T

Taylor Forge Canada Ltd., 1675 Burlington St. E., P.O. Box 511, Hamilton, Ont. L8N 3H8. Contact: J.R. Mink, 416- 862-0358.

Tech-Met Canada Ltd., 90 Milner Ave., Unit 9, Scarborough, Ont. M1S 3P8. Contact: John Wylie, 416-291-9831.

Technamould Corp., 1163 King Rd., Unit 16, R.R. #2, Burlington, Ont. L7R 3X5. Contact: Richard LaFleshe.

Technical Marketing Associates, #6, 6620 Kitimat Rd., Mississauga, Ont. L5N 2B8. Contact: Dr. D. White, 416-826-7752.

Tektrend International Inc., P.O. Box 322, Lachute, P.Q. J8H 3W8. Contact: D. Robert Hay, 514-935-8513.

Teledyne Thermatics, P.O. Box 909, Elm City, NC 27822. Contact: Franklin B. Brice, 919-236-4311.

• **Teledyne Wah Chang Albany,** 1600 N.E. Old Salem Rd., Albany, Oregon 97321. Contact: D.S. Fairgrieve, 503-926-4211.

Teleoperator Systems Corp., 45 Knickerbocker Ave., Bohemia, NY 11716. Contact: Carl R. Flatau, 516-567-8787.

Temcom Inc., 3030 Empire Ave., Burbank, CA 91504. Contact: M. Martin, 213-841-7450.

• **Tennatec Inc.,** 601 Oak Ridge Turnpike, P.O. Box 2560, Oak Ridge, TN 37830 - 2560. Canadian Representative: Radionics Scientific Inc., 585 Canarctic Dr., Downsview, Ont. M3J 2P9. Contact: Eleanor Duquette, 416-736-1600.

TGM Detectors Inc., 34 Bear Hill Rd., Waltham, MA 02154. Contact: Michael Dadarria.

Thyssen Marathon Canada Ltd., 6350 Vipond Dr., Mississauga, Ont. L5T 1G2. Contact: Ernst Peters, 416-675-5941.

Tiede GmbH & Co., Bahnhofstrasse 96, D-7081 Essingen bei Aalen, West Germany. Canadian Representative: Canadian NDE Technology Ltd., 18 Canso Rd., Rexdale, Ont. M9W 4L8. Contact: S. de Walle, 416-243-3456.

TIW Industries Ltd., 629 Eastern Ave., Toronto, Ont. M4M 1E4. Con1ct: T.B. Seawright, 416-461-8111.

Thomson Gordon Ltd., 3225 Mainway, Burlington, Ont. L7M 1A6. Contact: Cor Stakenborg, 416-335-1440.

Tracon Engineering Ltd., 520 Conestoga Rd., Waterloo, Ont. N2L 4E2. Contact: Bill Fraser, 519-884-2810.

Transduction Ltd., 1645 Sismet Rd., Unit 12, Mississauga, Ont. L4W 1Z4. Contact: Christopher Seepe, 416-625-1907.

Transmuclear Inc., One North Broadway, White Plains, NY 10601. Contact: Bill R. Teer.

Trecan Ltd., 4540 Dixie Rd., Mississauga, Ont. L4W 1N2. Contact: W.K. Lombard, 416-625-4030.

Tube Turns, Div. of Allegheny International Canada Ltd., 6711 Mississauga Rd., Ste. 509, Mississauga, Ont. L5N 2W3. Contact: J.F. Goodbrand.

Tuflino Div. of Xomox Canada Ltd., 222 Norfinch Dr., Downsview, Ont. M3N 1Y5. Contact: W. Ray Boreham, 416-661-6000.

U

Uddeholm Ltd., 5400 Dixie Rd., Mississauga, Ont. L4W 1E5. Contact: A.E. Cambon, 416-625-3300.

Unibraze of Canada Ltd., 99 Columbus St., Pointe Claire, P.Q. H9R 4K3. Contact: J. Mrenicie, 514-694-4801.

Union Carbide Canada Ltd., 123 Eglinton Ave. E., Toronto, Ont. M4P 1J3. Contact: B.L. England, 416-488-1444.

Union Pump (Canada) Ltd., 407 Speers Rd., Ste. 202, Oakville, Ont. L6K 3T5. Contact: M. Sexsmith, 416-842-4120.

United Electric Controls (Canada) Ltd., 5320 Bradco Blvd., Mississauga, Ont. L4W 1G7. Contact: Malcolm Quinn, 416-625-5082.

United Engineers & Constructors Inc., 30 S. 17th St., P.O. Box 8223, Philadelphia, PA 19101. Contact: Frederick R. Carpentier, 215-422-3849.

United Flexible of Canada Ltd., 128 Centre St. E., Richmond Hill, Ont. L4C 1A6. Contact: D.A. MacLeod, 416-883-5883.

Unitron Instruments Inc., 175 Express St., Plainview, NY 11803. Canadian Representative: Tech-Met Canada Ltd., 90 Milner Ave., Unit 9, Scarborough, Ont. M1S 3P8. Contact: John Wylie, 416-291-9831.

Universal Pipe Line Enterprises Ltd., 10,665 Henri-Bourassa E., Montreal, P.Q. H1C 1G8. Contact: S.B. Sandford, 514-325-8310.

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University of Manitoba — Cyclotron Lab., Physics Dept., Winnipeg, Man. R3T 2N2. Contact: M.I. Gusdal, 204-474-8201.

University of Saskatchewan, Dept. of Physics, Saskatoon, Sask. S7N 0W0. Contact: R. Montalbetti, 306-343-4271.

University of Toronto, Faculty of Applied Science & Engineering, Toronto, Ont. M5S 1A4. Contact: Prof. O.J.C. Runnalls, Energy Studies.

Uranerz Exploration & Mining Ltd., 204, 229 Fourth Ave. S., Saskatoon, Sask. S7K 4K3. Contact: Dr. G. Kirchner, 306-242-5101.

Utility Associates International, 6003 Executive Blvd., Rockville, Maryland 20852. Contact: R.L. Priem, 301-468-8604. Canadian Representative: A.H. Zohar, 50 Hallorown Place, Willowdale, Ont. M2J 1P7.

V

Valcor Engineering Corp., 2 Lawrence Rd., Springfield, NJ 08081. Canadian Representative: Finnan Engineered Products, 1149 Bellamy Rd. N., Unit 22, Scarborough, Ont. M1H 1H7. Contact: Hayward Hahn, 416-438-6070.

• **Velan Inc.,** 2125 Ward Ave., Montreal, P.Q. H4M 1T6. Contact: R.N. Rodricks, 514-748-7743.

Verbik Metals Corp., 3458 E. Olympic Blvd., Los Angeles, CA 90023. Contact: Robert Verbik.

Vereinigte Deutsche Metallwerke Canada Ltd., 2 Bloor St. E., Ste. 3100, Toronto, Ont. M4W 1A8. Contact: Helmut Klein, 416-961-9363.

P.F. Vermeer Ltd., 85 Ferrier St., Unit 5, Markham, Ont. L3R 2Y9. Contact: P. Vermeer.

Versatile Measuring Instruments Inc., 55 Six Point Rd., Toronto, Ont. M8Z 2X3. Contact: R.J. Campbell, 416-239-8241.

• **Versatile Vickers Inc.,** 5000 Notre-Dame St. E., Montreal, P.Q. H1V 2B4. Contact: J.R. Howett, 514-256-2651.

Vicom Ltd., 675 Development Dr., Kingston, Ont. K7M 4W6. Contact: John J. MacKay, 613-389-4660.

Henry Vogt Machine Co., P.O. Box 1918, Louisville, KY 40201. Contact: Sam Raderer, 502-634-1511.

W

E.H. Wachs Co., 100 Shepard St., Wheeling, Ill. 60090. Canadian Representative: Justram Equipment Co., 5 Industry St., Aurora, Ont. L4G 3L5. Contact: Tony Kunopaski, 416-727-2763.

Wachenhut of Canada Ltd., 1 East Mall Cresc., Islington, Ont. Contact: A.H. Sharpe, 416-239-2705.

• **W.L. Wardrop & Associates Ltd.,** 300 - 77 Main St., Winnipeg, Man. R3C 3H1. Contact: W.D. Christie, 204-956-0960.

W.C. Inv[illegible]ments Ltd., (includes Western Controls Inc.), 2 Chelsea Lane, Bramalea, Ont. L6T 3Y4. Contact: Klaus Adensamer, 416-791-2850.

Wood Instrument Company Inc., 707 Jeffrey Way, P.O. Box 300, Round Rock, Tx 78664. Canadian Representative: Cantech Controls, 1916 27th Ave. N.E., Calgary, Alta. T2E 7A5. Contact: D.A. Schmeeckle, 403-230-1581.

• **Weidmuller Terminations Ltd.,** 67C Steelcase Rd. W., Markham, Ont. L3R 2M4. Contact: Keith J. Sadler, 416-475-1507.

Western Stress Relieving Services Inc., Unit 11 - 1260 Fewster Dr., Mississauga, Ont. L4W 1A5. Contact: Craig Howe, 416-625-9100.

Westfield Minerals Ltd., P.O. Box 143, Ste. 3140, First Canadian Place, Toronto, Ont. M5X 1C7. Contact: T.N. McKillen.

• **Westinghouse Canada Inc.,** Dorset St. E., Port Hope, Ont. L1A 3V4. Contact: G.C. Brown, 416-885-4537.

Wiley Engineering Ltd., 422 Consumers Rd., Willowdale, Ont. M2J 1P8. Contact: M.D. Miller, 416-499-4421.

Wyle Laboratories, 7800 Governors Dr., Huntsville, Alabama 35807. Contact: David F. Dougherty, 213-322-1763.

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A.H. Zohar, 50 Hallorown Place, Willowdale, Ont. M2J 1P7. ■

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CANDU 600

Nuclear Generatin

Calandria and Shield Tank Assembly

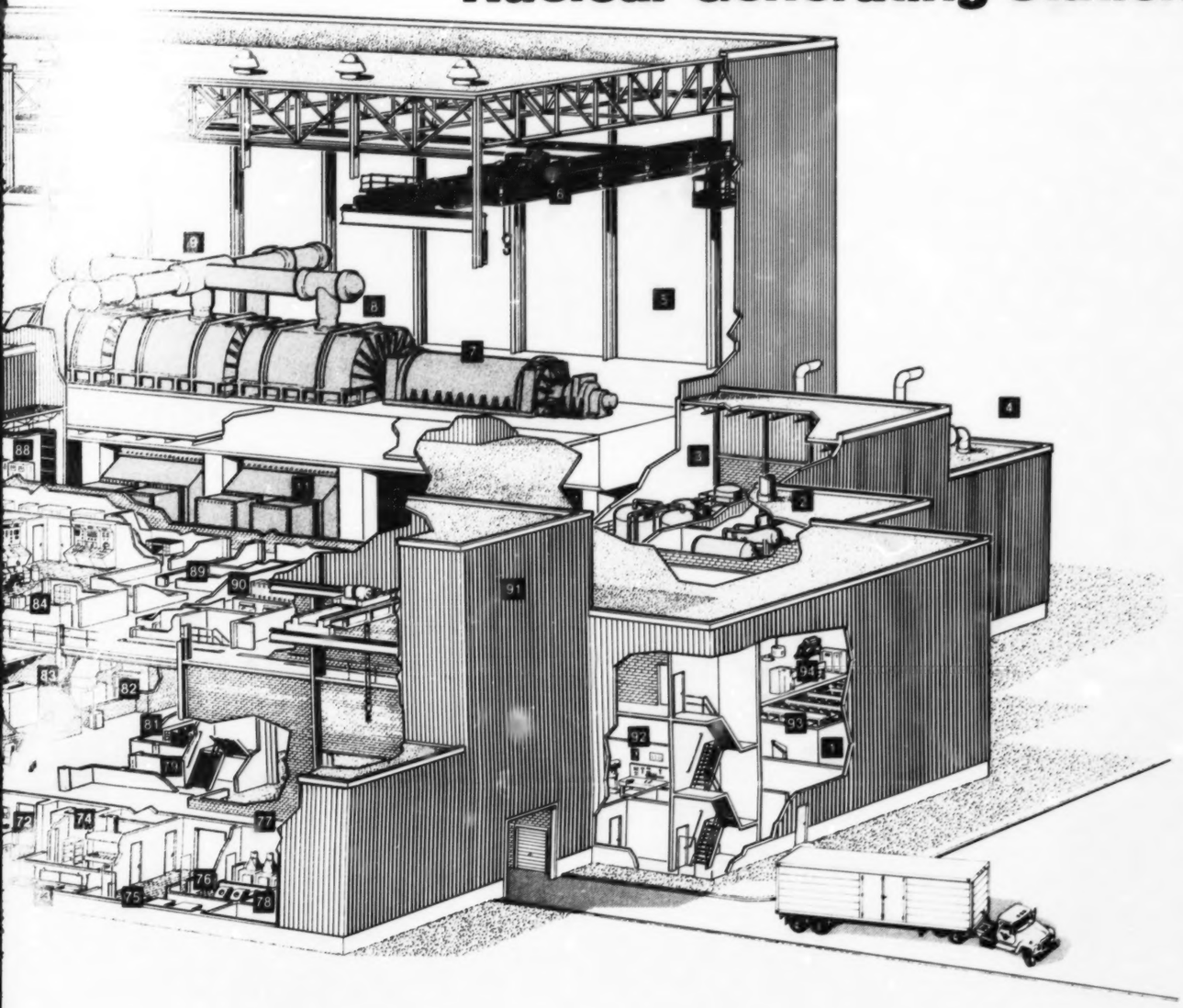
1. Calandria
2. Shutoff and control rods
3. Poison injection
4. Vault
5. Pressure tubes

CANDU 600 MWe Cutaway Key

1. General maintenance workshop
2. Water treatment plant
3. Water treatment plant
4. Diesel room
5. Turbine building
26. Bleed condenser
27. Bleed cooler
28. Hatch
29. Reactor vault
30. Pressure relief pipes
51. Moderator inlet pipe
52. New fuel handling machine
53. New fuel port
54. Fuelling machine service ports
55. Rehearsal facility
78. Plastic laundry
77. Drying room
78. Radiation protection storage
79. Elevator
80. New fuel storage

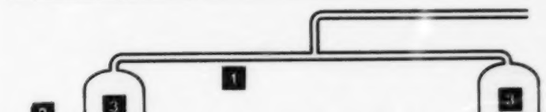
CANDU 600 MWe System Schematic

CANDU 600 MWe
Nuclear Generating Station

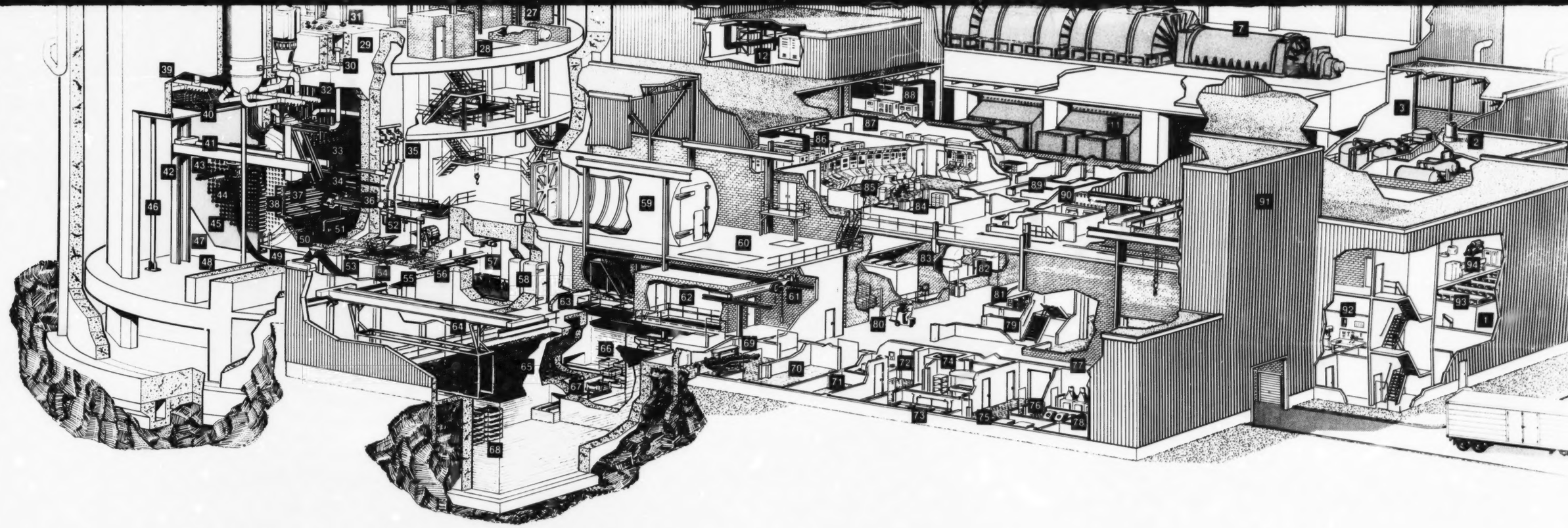


78. Plastic laundry
77. Drying room
78. Radiation protection storage
79. Elevator
80. New fuel storage

CANDU 600 MWe System Schematic

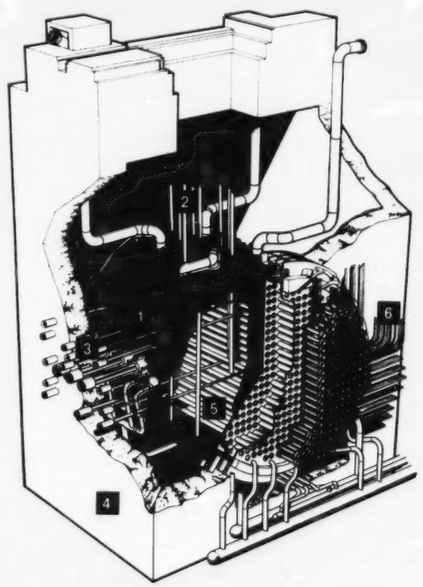


1. Steam pipes
2. Pressurizer
3. Steam generators
4. Primary pumps
5. Headers



Calandria and Shield Tank Assembly

1. Calandria
2. Shutoff and control rods
3. Poison injection
4. Vault
5. Pressure tubes
6. Feeder pipes



CANDU 600 MWe Cutaway Key

1. General maintenance workshop
2. Water treatment plant
3. Water treatment plant
4. Diesel room
5. Turbine building
6. Turbine building crane
7. Generator
8. Low pressure cylinders
9. Low pressure steam piping
10. High pressure cylinder
11. Condenser
12. Battery room
13. Boiler feed water tanks
14. Deaerator storage tank
15. Deaerator
16. Reactor building
17. Dousing tank
18. Dousing water supply pipes
19. Dousing water valves
20. Dousing water spray nozzles
21. Steam pipes
22. Steam generators
23. Pressurizer
24. Crane
25. Heat transport pumps
26. Bleed condenser
27. Bleed cooler
28. Hatch
29. Reactor vault
30. Pressure relief pipes
31. Reactivity mechanism deck
32. Reactivity mechanism support tubes
33. Calandria
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35. Poison tanks
36. Ion chambers
37. Pressure tubes
38. End shield
39. Headers
40. Feeder pipes
41. Fuelling machine bridge
42. Bridge support column
43. Fuelling machine
44. Catenary
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46. Steam generator support column
47. Feeder pipe insulation cabinet
48. Fuelling machine vault door
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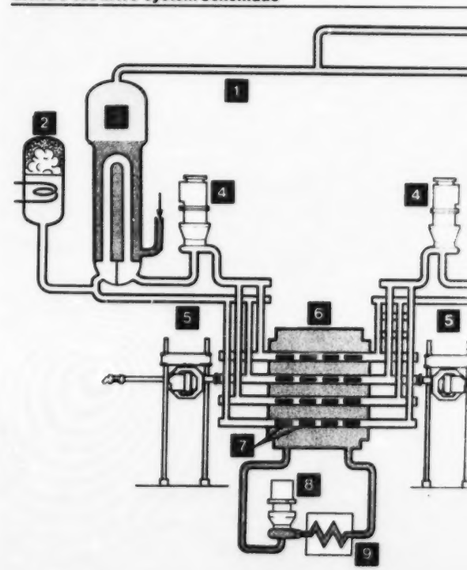
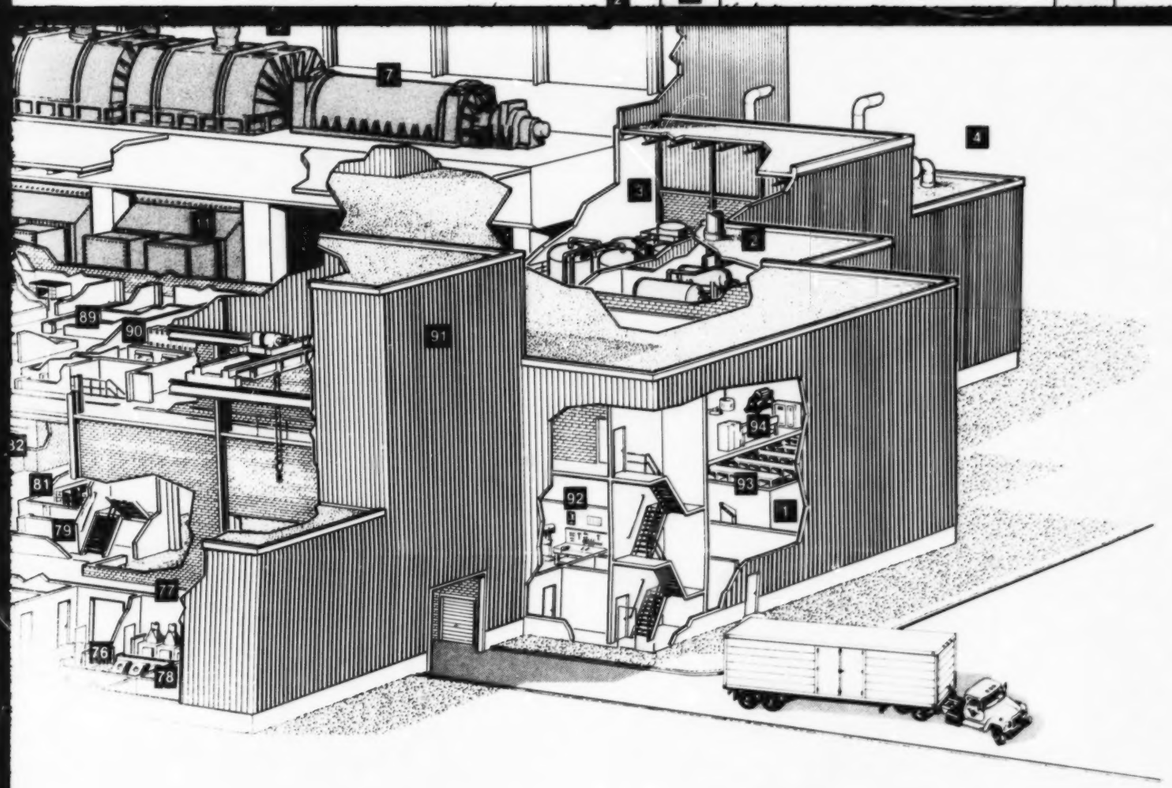
50. Fuelling machine track
51. Moderator inlet pipe
52. New fuel handling machine
53. New fuel port
54. Fuelling machine service ports
55. Rehearsal facility
56. Irradiated fuel port
57. Irradiated fuel elevator
58. Entrance to spent fuel area
59. Airlock
60. Lay down area
61. Crane
62. Irradiated fuel shipping area
63. Irradiated fuel handling area
64. Irradiated fuel bay gantry.
65. Irradiated fuel storage bay
66. Irradiated fuel transfer baskets
67. Irradiated fuel transfer trolley
68. Irradiated fuel storage baskets
69. Fuelling machine maintenance area
70. Decontamination room
71. Fixed activity stores
72. Monitoring room
73. Manual washroom
74. Monitoring cubicle
75. Soaking room
76. Plastic laundry
77. Drying room
78. Radiation protection storage
79. Elevator
80. New fuel storage
81. Tool crib
82. Air conditioning equipment
83. Radioactive waste tanks
84. Office
85. Control room
86. Control equipment room
87. Computer room
88. Electrical room
89. Offices
90. Wash and change rooms
91. Crane hall
92. Mechanical workshop
93. Electrical workshop
94. Stores

CANDU 600 MWe System Schematic





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76. Plastic laundry
77. Drying room
78. Radiation protection storage
79. Elevator
80. New fuel storage
81. Tool crib
82. Air conditioning equipment
83. Radioactive waste tanks
84. Office
85. Control room
86. Control equipment room
87. Computer room
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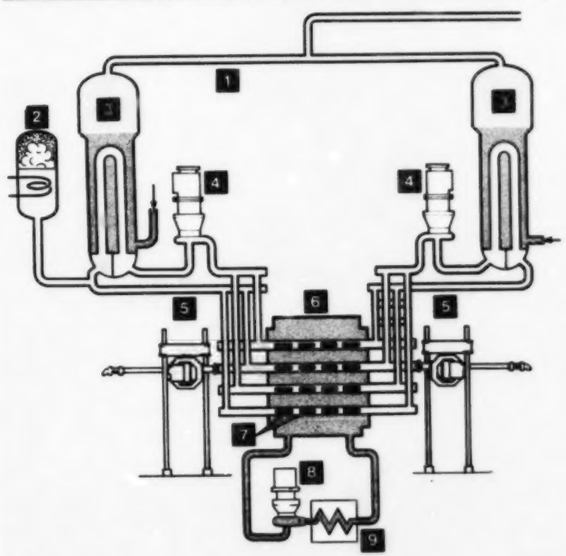
89. Offices
90. Wash and change rooms
91. Crane hall
92. Mechanical workshop
93. Electrical workshop
94. Stores

CANDU 600 MWe System Schematic



1. Steam pipes
2. Pressurizer
3. Steam generators
4. Primary pumps
5. Headers
6. Calandria
7. Fuel
8. Moderator pump
9. Moderator heat exchanger

Light water steam
Light water condensate
Heavy water coolant
Heavy water moderator

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